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Candid Chats

Nobody Admires a Faker

IF a fighter is discovered using brass knuckles, or an umpire calls strikes for balls, or a marathon runner steals a ride or fouls another intentionally, we all but foam at the mouth as we protest against such tactics. We must have clean sport!

We also demand clean tactics in business, generally, but once in a while there comes to the surface a story of unfair dealing that reflects discredit on all involved.

We are ever watchful to discover and condemn a central station company when its manner of doing and getting business is questionable or openly in violation of fair dealing. That's right.

If we know the plant is being operated as economically as good practice permits and its records show what it is doing we don't fear honest competition from a power company. We know we are doing all that can be done, and that, if given a fair chance, we can hold the plant. But if we are hard pressed by the power company, if we are not prepared to meet the competition, we have not done all we could and should. We know we are quite sure to suffer for it.

Under such circumstances wouldn't it be ridiculous for an engineer to try to "get by" by resorting to unfair tactics? Don't you think that a man who has long operated a plant this way is foolish to believe that he can deceive a trained engineer who comes to test the plant for the very purpose of finding the "leak spots" which are there for him to find? Of course you do.

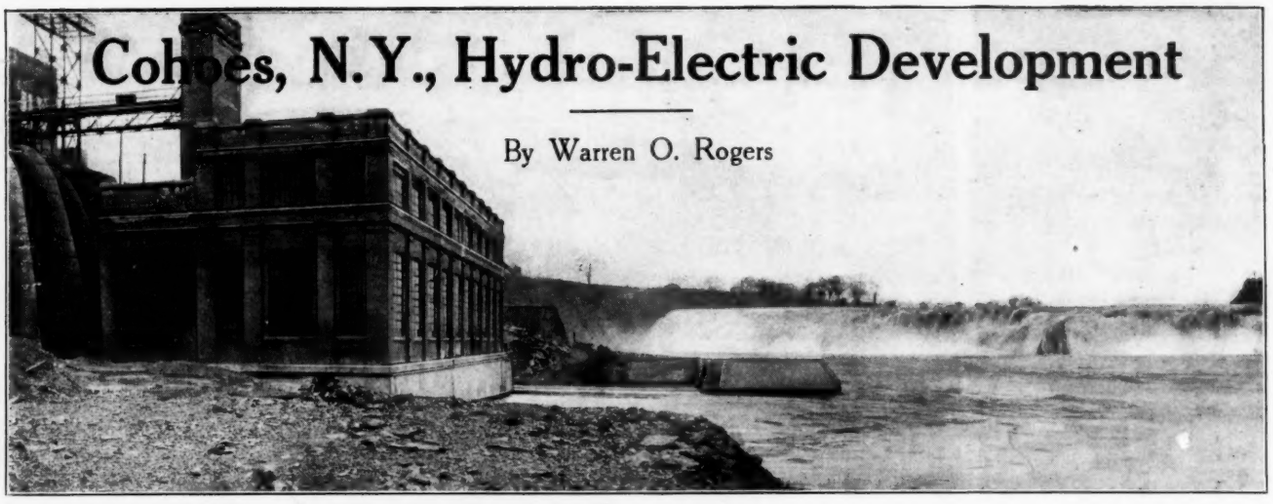
To try and deceive by producing "padded" reports and faked readings is to put oneself on a par with the fellow who said the combustion chamber was too full of soot to be emptied. Boiler settings that leak like a sieve cannot be made tight by putting a certain figure on a report sheet. Fire clay and waste will make a better job. The coal used to heat water and make steam that is blown to the sewer may be accounted for on paper in many ways; but that does not reduce the coal bill. A "padded" report sheet may say that the coal consumption per kilowatt-hour is very low, but the trained engineer knows there is a "bug" in the figures when an examination of the plant shows large preventable losses at each stage of the generation of those kilowatts.

Comparatively few engineers stoop to fake in this manner. Recently I heard of a case where a central station got the job of heating and lighting a large building. To make it more difficult for the power company to meet its contract, the engineer allowed steam to blow to the sewer direct from the boiler. Of course he was discovered.

That's not the way to meet central station competition. A square deal is demanded of the central stations. Treat them fair.

Do all you can to procure for the plant those things needed to get the data necessary to record the plant's performance. Be sure you need that for which you are going to ask. Estimate closely what saving will come from the investment you want the boss to make. Then go to him determined to show that these things are needed. You are not asking a favor, and don't talk as though you were.

If you cannot get what you need, and lack of means prevents you from getting good results from the plant, do your best. But don't fake report readings. Your reputation will not be hurt if you quit that job and get another, where you can show good results. It would be hurt if you were discovered to be a faker.



Cohoes, N.Y., Hydro-Electric Development

By Warren O. Rogers

SYNOPSIS—Hydro-electric plant, with an initial capacity of 27,000 kv.-a. and a maximum of 45,-000, will supplant numerous old, inefficient mill waterwheels. The present waterwheel capacity is 30,000 hp. in three 10,000-hp. turbines, with an ultimate capacity of 50,000 hp. The water is brought to a forebay through a canal the inlet of which is at the dam, farther up the river. All electrical apparatus is segregated in bays, both on the generator-room level and in a gallery in the switch-house. Electrically operated gates in the gatehouse on the cliff are controlled both from the gatehouse and from the main switchboard.

The hydro-electric development of the Cohoes Co., Cohoes, N. Y., now practically completed, will supplant the old hydraulic canal which has supplied water to the various mills along its banks for something like eighty-five years. The separate water-power plants of the individual mills will be shut down and electrical energy will be supplied from the new power plant, which, with its initial installation of 30,000 hp. in waterwheels and 27,000 kv.-a. in generators, will eventually be increased to 50,000 hp. in turbine and 45,000 kv.-a. in generator capacity.

As understood, the various mill water plants are both old and inefficient and do not economically utilize the head available; the output of the new plant will exceed the total capacity of the individual mill plants. For the present most of the energy generated by the three units installed will be utilized in Cohoes and the vicinity, and as the transmission distance is short, the energy is generated at 12,000 volts, no step-up transformers being used.

Ninety-eight years ago the Cohoes Co. was incorporated as a power and manufacturing company and purchased land in what is now the City of Cohoes and a strip on the other side of the river. It also secured the water power and control of the river from half a mile above Cohoes Falls to a mile below, with the exception of a reservation made by the state for canal purposes. The river, above the falls, drains an area of about 3,500 sq.mi. and the total fall is about 120 ft.

When the new power plant was proposed the company already owned a dam and a canal system totaling about three miles on various levels and supplying water to drive the various waterwheels in the city.

The company also has two small hydro-electric generating stations—one on the present canal system, which will be held in reserve, and another some distance further down the river at an independent masonry dam 1443 ft. long. The latter plant contains one 200-kw. 2,300-volt 60-cycle two-phase unit. It is planned to change it to 40 cycles and operate it in parallel with the new station. A steam plant in the Harmony Mills, consisting of a 2,500-kw., 600-volt, 40-cycle, three-phase unit, will be retained, but

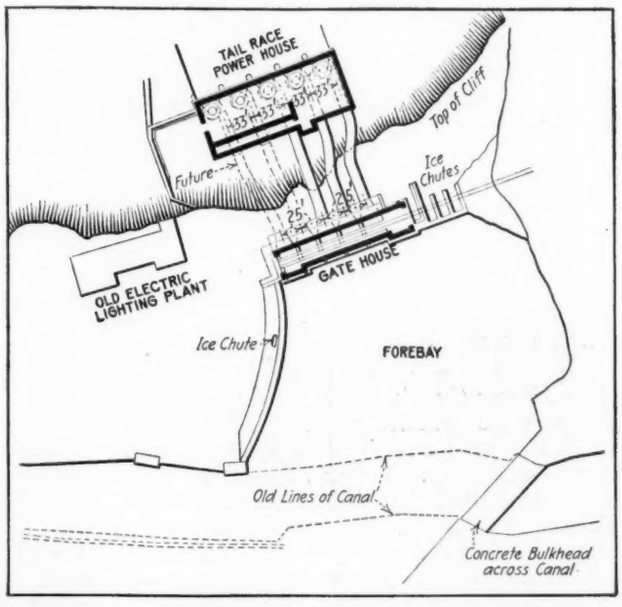


FIG. 1. ARRANGEMENT OF FOREBAY, GATEHOUSE, PENSTOCK AND POWER HOUSE

no water from the canal will be used for operating the turbines of this mill. This steam plant will be available for breakdown service for the new station.

The new power station is about 1,000 ft. below a natural fall in the Mohawk River and utilizes water from the present power canal. About 3,000 ft. above the falls is the old dam of the company, with its crest at an elevation of 157 ft. above tidewater. As the low-water level elevation at the power house is 58 ft., the available head is 99 ft. This varies with the stage of the water in the river, and the average head will be about 96 ft. The high-level canal of the company is fed from the river at the upper dam.

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To provide sufficient water for the new power plant when it is completed, the power canal between the dam and the forebay has been enlarged to a cross-section of 1200 sq.ft. When the two future units are installed, it will be necessary to enlarge the canal by digging away one of the banks. By doing this and using flashboards on the dam, the forebay level will be 3 ft. higher than at present.

Forebay and Gatehouse

Above the power plant and between the gatehouse and the power canal a forebay of about seven acres surface area has been built. This was necessary in order to supply sufficient water when a load is suddenly thrown on the station. When this occurs the units require a large amount of water at once, which is supplied by the volume in the forebay until the flow of water in the canal increases in volume and velocity to take care of the extra demand. The masonry surrounding the forebay is carried 2 ft. higher than the maximum water level, or to elevation 160; the water level will vary between elevations 153 and 158. Four small ice chutes closed by hand-operated wooden gates are provided in the forebay wall. These permit the flow of water to carry out ice, debris, etc. The forebay can be drained by a 36-in. sluice gate through the base of the wall. Fig. 1 shows the layout of the forebay, gatehouse, penstocks and the power house.

Above the power plant on the edge of the bluff is the gatehouse, Fig. 2, containing five gate bays. In the rear of the upstream stop wall are the racks, made of 3½x5⅛-in. round-edge steel bars, spaced 3 in. on centers. The length of the racks is 125 ft., and they are submerged 23 ft. This arrangement of one long rack permits water to be drawn from a large area and prevents trouble should the rack in front of one particular gate become clogged.

Headgates and Penstocks

As the power plant will ultimately contain five units, provision has been made for that number of headgates,

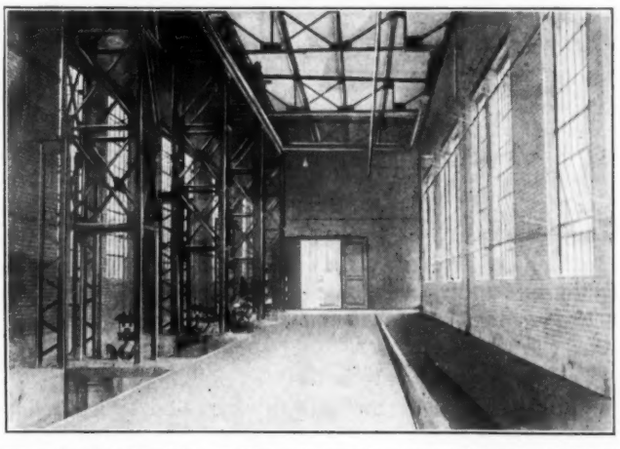


FIG. 2. INTERIOR VIEW OF THE GATEHOUSE, WHICH IS BUILT ON THE BLUFF ABOVE THE POWER PLANT

20 ft. wide and 22 ft. high. Three have been placed, each closing the intake of one penstock. Each intake is 18.5 ft. wide and 15 ft. high. The gates are of the Stoney type and are arranged to rise and fall on rollers. Each is operated by a 220-volt, 22-hp. induction motor through a cable drum on either end. The control boards for the motors are in the brick gatehouse. The gates may also be controlled from the switchboard in the power house. Each control board has three buttons—one for opening, one for closing and one for arresting the travel of the gate in any mid-position. Over-travel is prevented by a limit switch on each motor, equipped with an electric brake. A traveling hoist is provided for handling the racks and stop logs when necessary.

Three penstocks, 11 ft. diameter and 190 ft. long, the vertical distance being 100 ft., each supplying one water-

FIG. 3. THREE 11-FT. STEEL PENSTOCKS, 190 FT. LONG

wheel, are at present constructed, together with such parts of two others as are embedded in the concrete substructure of the gate and power houses. The steel penstocks, Fig. 3, range from ⅜ to ½ in. in thickness and are anchored by heavy rods embedded in rock and concrete near the top elbow, and frequent concrete saddles are provided; those at the lower elbows are merged into the heavy substructure of the power house. From the gatehouse, which is 150 ft. long, 28 ft. wide and 31 ft. high, the penstocks curve at a radius of 30 ft. and descend over the face of the cliff to the power house, where the curve is at the same radius. They are reinforced by stiffening rings of 6x4x½-in. angle bars riveted to the pipe and spaced about 11 ft.

Power-House Details

The power house is about 170 ft. long and 60 ft. wide. It is constructed with the generator floor extending its length and with a switchboard gallery under which are 10 bays that are utilized for several purposes.

The three generating units, Fig. 4, are spaced 33 ft. center to center. The three 10,000-hp. vertical-shaft, single-runner Francis wheels are made with cast-iron scroll cases. They have a combined radial and axial flow, and a single downward discharge into concrete draft tubes.

The draft tubes are circular at the top, 7½ ft. in diameter and change to an oval 11½ ft. high and 31 ft. long, which reduces the runner discharge velocity from about 25 ft. per sec. to 4½.

The center of the wheels is at an elevation of 69 ft., or 89 ft. below the maximum level of the water in the forebay and 11 ft. above the low-water level in the tail-race. They are mounted below the station floor and run at 185 r.p.m. The guaranteed efficiencies of the water-wheels under the normal head of 96 ft. and at a constant speed of 185 r.p.m. are as follows:

Hp.	Per Cent.	Hp.	Per Cent.
10,000	85	7,000	86.5
9,000	87	6,000	84
8,000	88	5,000	80

With a speed regulation based on a total flywheel effect of 1,700,000 ft.-lb., a penstock diameter of 11 ft. and a length of 190 ft., the different load changes are as follows:

	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Load change.....	10	25	50	100
Speed change.....	0.9	2.1	3.5	16

The runner is 75 in. diameter and the weight of the waterwheel complete is 135 tons; the weight of each volute casing is about 60 tons and that of the runner 7½ tons.

Each turbine shaft carries the rotating field of a 9000-kv.-a. (7200-kw., 0.80 per cent. power factor), 12,000-volt, three-phase, 40-cycle alternator. The rotor of each unit is supported on a Kingsbury bearing designed for a static load of 160,000 lb., which is carried by a bridge yoke on the generator frame. The generators have been designed with a margin of field excitation sufficient to give the full output at any voltage between 11,500 and 12,700, at 80 per cent. power factor.

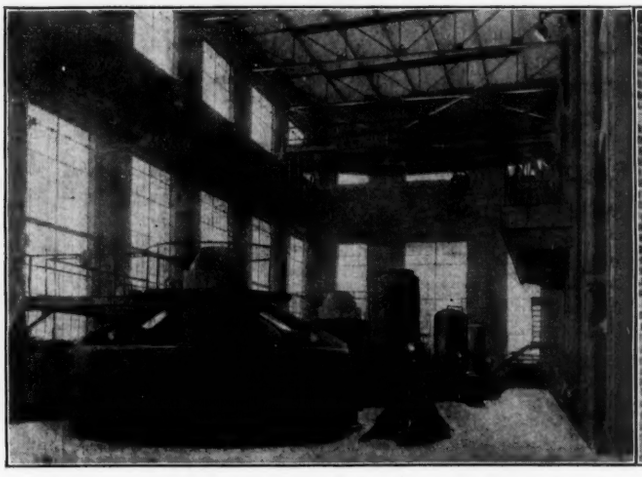


FIG. 4. SHOWING THE THREE 9,000-KV.-A. GENERATORS WHICH ARE DRIVEN BY THREE 10,000-HP. FRANCIS WHEELS

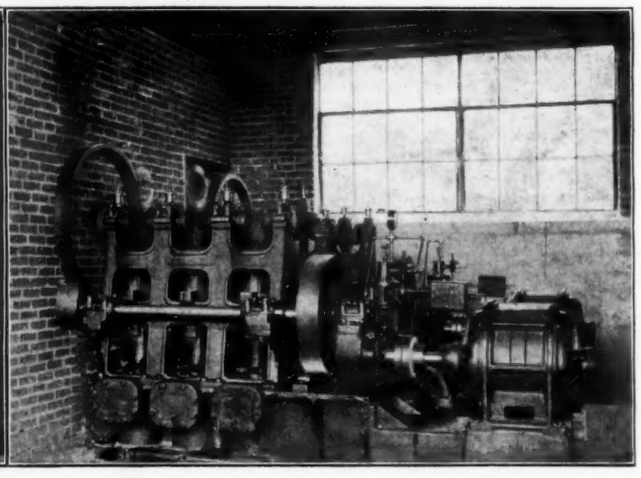


FIG. 5. MOTOR-DRIVEN PLUNGER OIL PUMPS. THE PRESSURE IS AUTOMATICALLY REGULATED BY BYPASSING THE OIL

At normal load and at 0.80 per cent. power factor, the temperature rise will not exceed 50 deg. C. The guaranteed efficiencies are:

	Full Load	¾ Load	½ Load
9000 kw., 1.0 power factor.....	96.9	96.3	94.8
7200 kw., 0.9 power factor.....	96.0	95.3	93.5

The generators are designed with an internal reactance to limit the current of each under short-circuit conditions to about eight times the normal full-load value.

The rotor spider is made of a solid steel casting and the complete rotor is designed to withstand 65 per cent. overspeed.

The shaft of each unit is made in two pieces coupled together with a heavy flange coupling below the rotor. The periphery of the coupling is finished and on it is placed a powerful hand-operated flexible-steel oak-block-lined band brake, capable of stopping the revolving element within five minutes. The speed of the unit is governed by a flyball governor which controls the oil supply to the cylinders (servo motors) of 60,000 ft.-lb. capacity, whose pistons shift the guide-vane rings. The governor is driven by a set of straight gears which drive a countershaft provided with a set of bevel gears. The steady bearing of each unit is 40 in. long, lined with lignum-vitæ strips and lubricated by water brought from the gatehouse through a 3-in. pipe line.

Lubricating System

Oil for operating the "servo motors" is drawn from a 37-in. diameter by 9-ft. 8-in. high tank located close to the governor of each unit and between the high-pressure oil-supply line and the relay valve of the governor which controls the servo motor. Pressure losses in the system are prevented by filling the upper part of each oil tank with air under pressure from a 10-hp., motor-driven, 6x6-in. water-cooled air compressor, which is run as required and supplies air at a rate of 10 cu.ft. per min. The two 5½x8-in. triple plunger oil pumps are each driven by a 25-hp. induction motor at 760 r.p.m. and run continuously. One pump is held as a spare, and provision has been made for a third unit. The oil pressure is maintained at 200 lb. and each pump has a capacity of 100 gal. of oil per min. at 45 r.p.m. The difference in speeds between the motor and pump is made by a combination of gear drive. These units are in the second bay and in the basement below is the oil-supply tank. The oil upon entering the tank goes to one compartment and passes through a brass-wire screen to another.

When the oil pressure in the system builds up above the 200 lb. carried it is automatically bypassed by a regulating device attached to the discharge line of the pump. This is shown between the motor and pump, Fig. 5.

The oiling system, Fig. 6, is of the gravity type; that is, the oil is conveyed by gravity from the overhead storage reservoirs to the Kingsbury thrust and guide bearings. The used oil flows by gravity to the filter, and after being purified and cooled is returned to the overhead storage reservoir by two 3-hp. motor-driven centrifugal pumps. The 3-in. discharge pipes from these pumps enter the overhead supply tanks at the top. A 3-in. overflow pipe from each tank runs to the return tank, which contains

several compartments having cooling coils and filter bags. The oil is cooled by water taken from the gatehouse.

The system is designed to furnish continuously 12 gal. of oil per min. to each of the five units (three now in operation) making a total of 60 gal. per min. for the ultimate capacity.

The filter is of the central-station type and is constructed of $\frac{5}{16}$-in. steel plate with a holding capacity of approximately 1200 gal.

The two overhead reservoirs are 10 ft. long by 3 ft. in diameter and each generator unit is equipped with one recording and four indicating thermometers, two sight-flow indicators with electrical connections, and two integrating oil meters. The main supply line is also equipped with one indicating oil thermometer.

Each feed line on the main units is equipped with a brass-body oil strainer which contains fine-mesh wire screen and is self-cleansing. The object of this strainer is to prevent any particles of foreign matter in the pipe lines between the filters and generators from getting into the bearings.

The sight-flow indicators are equipped with electrical contacts, so that should the supply of oil to a bearing drop below a certain predetermined amount, the indicator flap will close the circuit, ringing a bell and indicating on an annunciator where the drop in flow takes place.

Two motor-generator sets for field excitation are installed in the third bay, Fig. 8. The motors are of the squirrel-cage induction type, and are each of 250 hp. operating at 2300 volts. The compound-wound generators

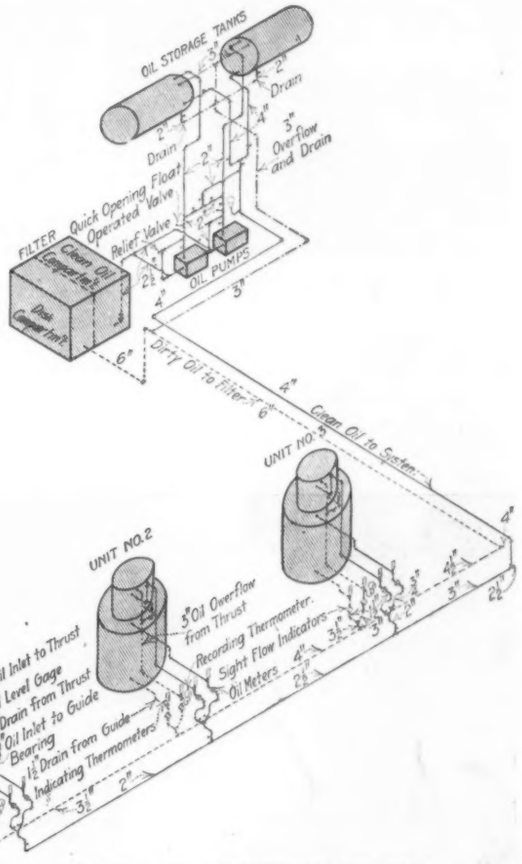


FIG. 6. OILING AND FILTERING SYSTEM

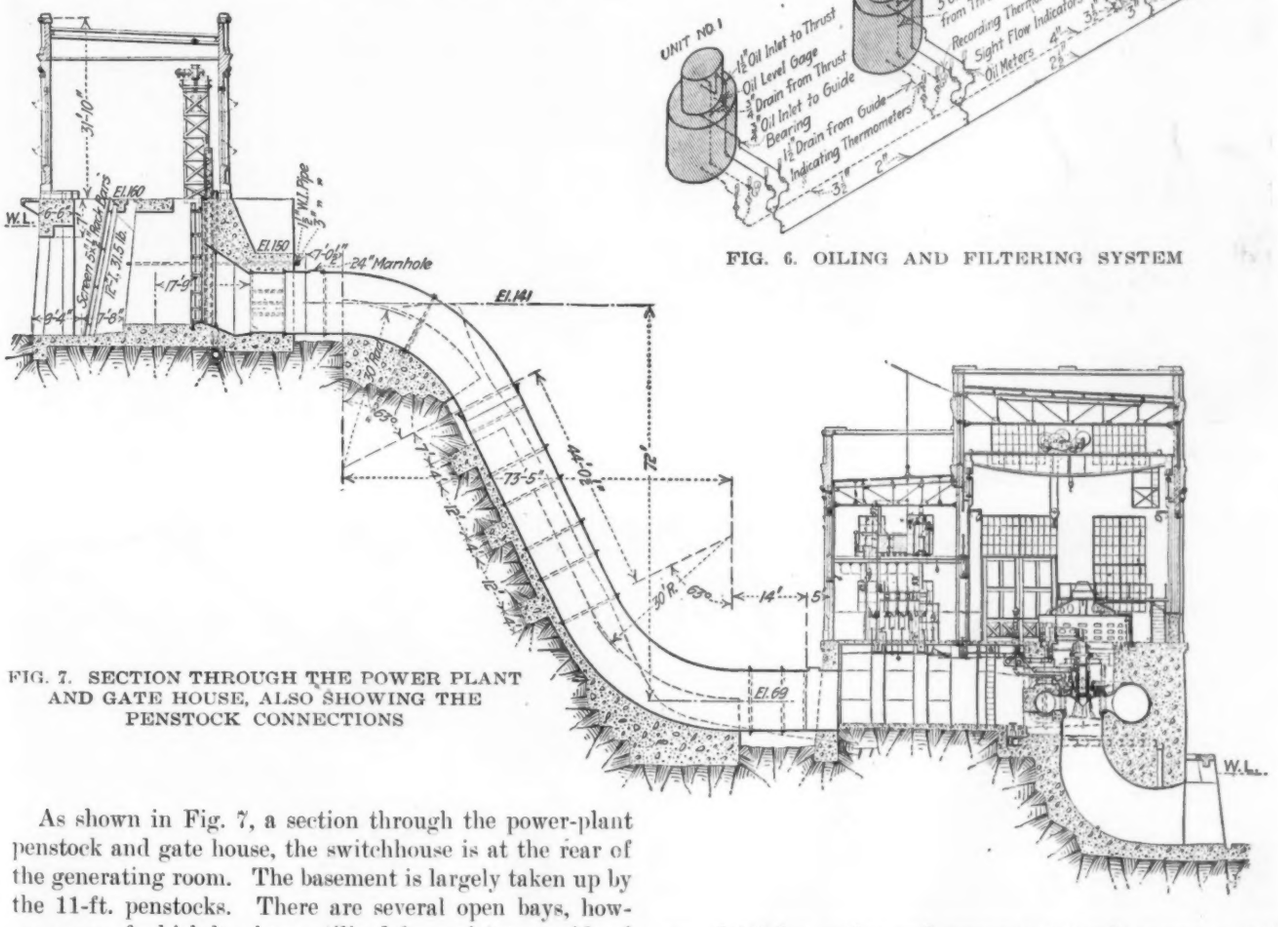


FIG. 7. SECTION THROUGH THE POWER PLANT AND GATE HOUSE, ALSO SHOWING THE PENSTOCK CONNECTIONS

As shown in Fig. 7, a section through the power-plant penstock and gate house, the switchhouse is at the rear of the generating room. The basement is largely taken up by the 11-ft. penstocks. There are several open bays, however, one of which has been utilized for resistance grids of the generator-field circuit control. This bay is ventilated by several cold-air inlets and a hot-air flue that extends above the elevator tower, escaping at the top; or when desired, the hot air is discharged to the main and gallery floors of the switchhouse.

are of 165-kw. rating and generate 250-volt energy at 780 r.p.m. Provision has been made for a third set in the bay. It will be observed that this station is not equipped with a water-turbine-driven exciter, it being considered unnecessary, as electrical energy for operating the exciter motors can be obtained from other generating plants in case

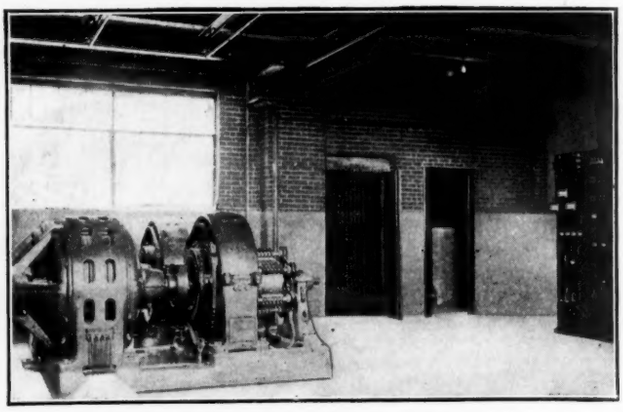


FIG. 8. PARTIAL VIEW OF THE EXCITER BAY

all of the generators in this plant should be shut down. On the opposite side of the bay are the switchboard panels for controlling the exciter, station lighting and power circuits. There is also a 3.5-kw., 110-volt, induction-motor-driven battery booster at the rear and at the inner end of the switchboard. The entrance to the elevator connecting to the walls leading to the gatehouse is in this bay.

Fig. 9 shows the fifth bay, in which there are two banks of 800-kw. capacity step-down transformers, two-phase, 2300-volt service for the City of Cohoes, also two three-phase, 12,000-volt electrically operated oil switches. The next three bays are shown in Fig. 10, and contain the 12,000-volt busbars of copper tubing, supported from the floor beams above, the generator feeder and bus-sectionalizing oil switches and their disconnecting switches; also their current and potential transformers.

On the gallery, the first three bays of the switchhouse are devoted to the apparatus for the 2300-volt, two-phase circuits for Cohoes, Fig. 11. At present there are two motor circuits and four single-phase house-lighting circuits with their automatic-feed regulators; also four 75-lamp, constant-current transformers for series street lighting are installed. There are oil switches for the low-tension side of the 800-kw. transformer banks, switches for controlling the high-tension side of the station transformers, and the starting and running exciter switches.

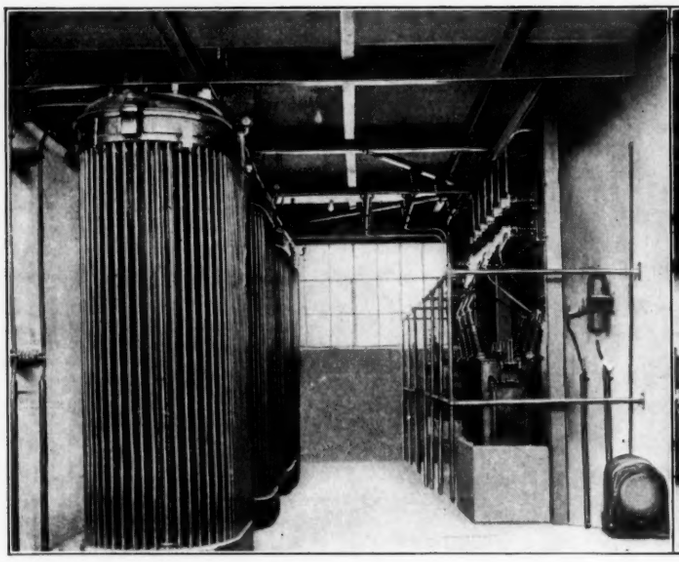


FIG. 9. STEPDOWN TRANSFORMERS AND OIL SWITCHES

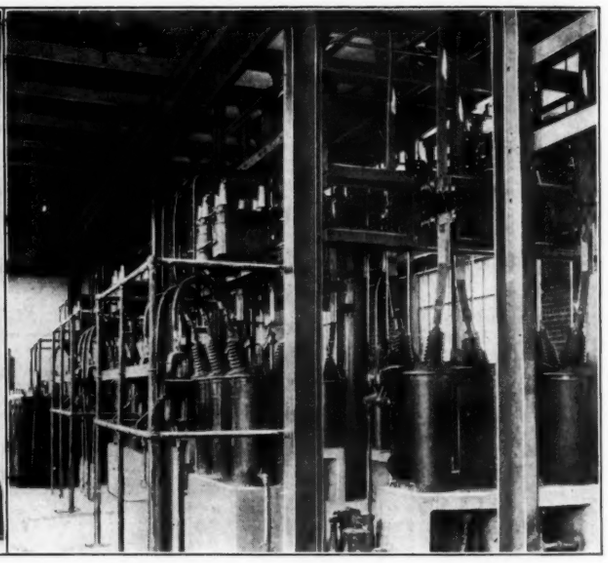


FIG. 10. BUSBARS, OIL AND DISCONNECTING SWITCHES

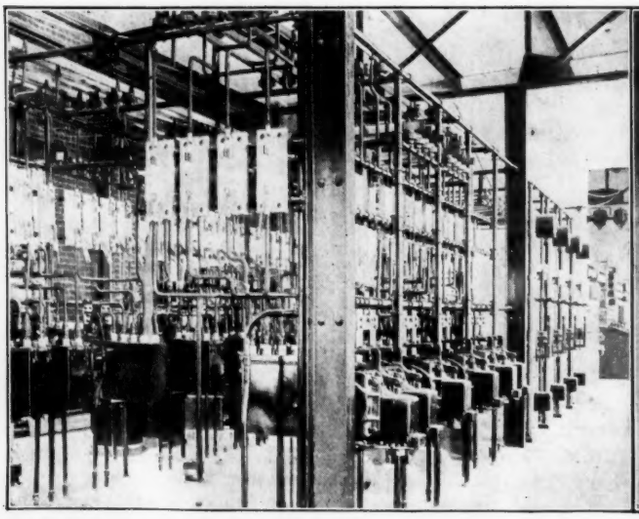


FIG. 11. CONTROL BOARD AND MAIN BENCH BOARD IN THE DISTANCE. STRETCHER AND OVERHEAD BUSBARS IN FOREGROUND

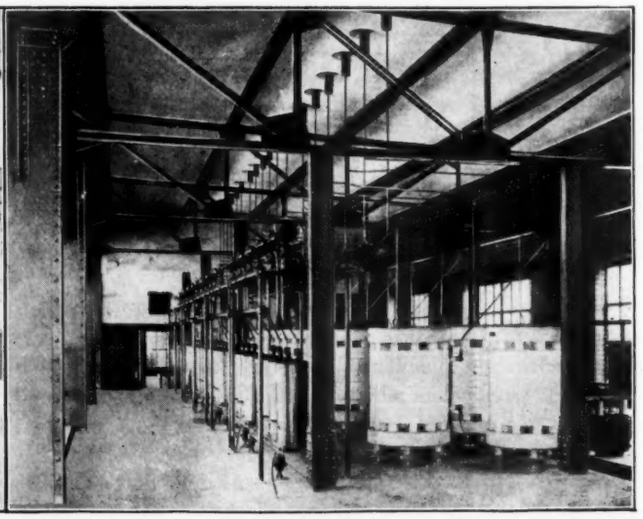


FIG. 12. PROTECTIVE REACTANCE AND ELECTROLYTIC LIGHTNING ARRESTERS

In the next two bays are the 2300-volt control board and the main benchboard, shown at the right of Fig. 11. Two auxiliary switchboards are located behind the 2300- and 12,000-volt switchboard, and carry the recording meters and testing plugs for the circuits controlled from the main switchboard panels.

Passing from the switchboard bays, which are partitioned off from the three remaining bays, the porcelain-clad protective reactances and electrolytic lightning arresters, Fig. 12, for the six 12,000-volt circuits are installed. Fig. 13 is a plan of the generator room and switchboard gallery. The six outgoing high-tension lines are dead-ended at the building. The lines leave the station through the roof. There are also two outgoing low-tension, two-phase, four-wire motor circuits, four single-phase house-lighting circuits and two street-lighting circuits.

Sanderson & Porter, New York City, were the designing and supervising engineers.

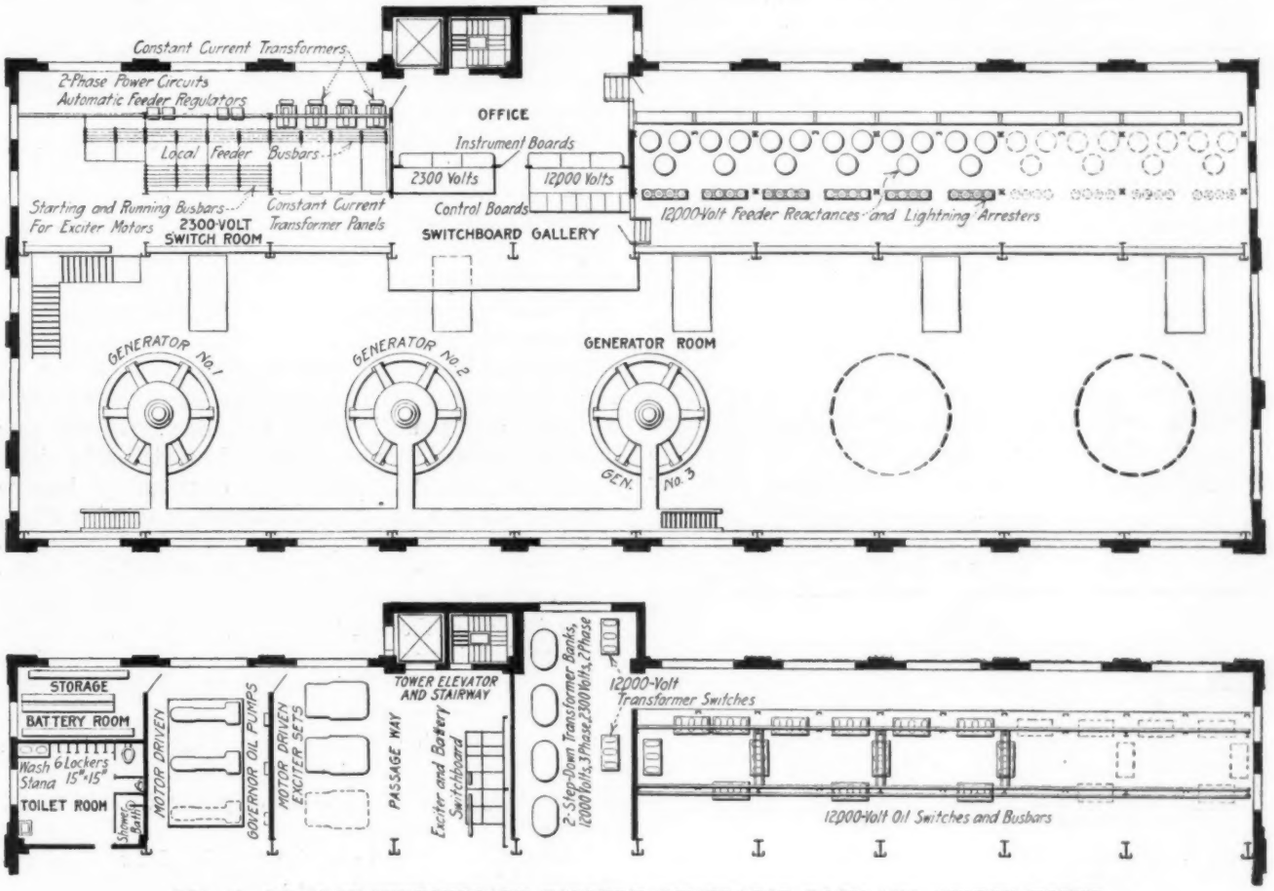


FIG. 13. PLAN OF SWITCHBOARD GALLERY, GENERATOR ROOM AND SWITCH HOUSE

PRINCIPAL EQUIPMENT OF THE COHOES HYDRAULIC POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Turbines	Francis, single runner	10,000-hp.	Driving main generators	96 ft. head, 185 r.p.m.	Platt Iron Works
3	Generators	Vertical, alternating	9000-kv.a.	Main units	185 r.p.m., 12,000 volts, 3-phase, 60-cycle	General Electric Co.
3	Governors	Lombard, special		Waterwheel control	Gear-driven, oil-controlled	Lombard Governor Co.
3	Motors	Induction	22-hp.	Operating penstock gates	220 volts, intermittent	General Electric Co.
3	Bearings	Kingsbury	160,000 lb. load	With generator shafts		Westinghouse Machine Co.
1	Compressor	Air, water-cooled	6x6-in.	Oil governor system	Motor-driven	Gardner Governor Co.
1	Motor	Induction	10-hp.	Driving air compressor	1140 r.p.m., 220 volts	General Electric Co.
2	Pumps	Triplex, plunger	5½x8 in.	Pumping governor oil	200 lb. oil pressure, 45 r.p.m.	Platt Iron Works
2	Motors	Induction	25-hp.	Driving triplex pumps	760 r.p.m., 220 volts, 3-phase, 40-cycle	General Electric Co.
2	Generators	Direct-current	165-kw.	Exciters	Motor-driven, 780 r.p.m., 250 d.-c. volts	General Electric Co.
2	Motors	Induction	250-hp.	Driving exciter generator	780 r.p.m., 2300 volts, 3-phase, 60-cycle	General Electric Co.
2	Regulators	Mason		Oil-pressure regulators	Automatic	Mason Regulator Co.
1	Booster	Battery	3½-kw.	With storage batteries	110 volts	General Electric Co.
18	Reactance	Porcelain-clad	12,000 volts			Metropolitan Engineering Co.
1	Battery	Storage	60-cell	Control circuits and emergency lighting	200 amp., 1250 volts	Electric Storage Battery Co.
1	Oiling system	Gravity	60 gal. per min.	Thrust, guide bearing lubrication, gravity		Peterson Engineering Co.
	Switchboard, transformers, lightning arresters and other electrical apparatus.					General Electric Co.

Elastic Limit and Yield Point

In a paper presented to the Canadian Railway Club it was pointed out that the engineering expressions, elastic limit and yield point were greatly abused in metallurgy. The yield point is commonly considered as being approximately one-half of the tensile strength, but in experiments with the Martens, or mirror-type, extensometer it has been found with ¾-in. flange steel that the true elastic limit is in general about two-thirds of the yield point. The difference in the value of the elastic limit of a material when the extensometer was used and when the reading was taken by the drop of the beam was mentioned.

In one case which was cited the extensometer showed the elastic limit to be 49,000 lb. per sq.in., while the drop-of-the-beam method showed 61,000 lb. per sq.in. The manufacturer thus has an excessive amount of leeway unless the method of test is stipulated in the specifications. The importance of a microscopic examination of the steel's structure was also emphasized. Such an examination furnishes data as to the way in which the steel is made and treated; while the analysis of two pieces may show the same composition the microscope will reveal clearly whether it is of the correct mechanical structure.

Motors Operated Under Modified Conditions

By Gordon Fox

SYNOPSIS—Suggestions for operating direct- and alternating-current motors at speeds, voltages or frequencies different from those rated.

Whenever it becomes necessary to meet special conditions, it is desirable that an endeavor be made to use standard apparatus. A study should be made of the possibilities of slight modifications in ratings, connections or usage to adapt standard or available equipment to the special needs, as such apparatus can be purchased much more cheaply than special equipment and more prompt shipments can be made. Moreover, in case of breakdown, repairs and parts can be more readily secured.

Direct-Current Motors

The cases most likely to arise in the use of direct-current motors are in securing different speeds than rated or in operating upon a different voltage. It is easy to change slightly the load speed of the ordinary shunt- or

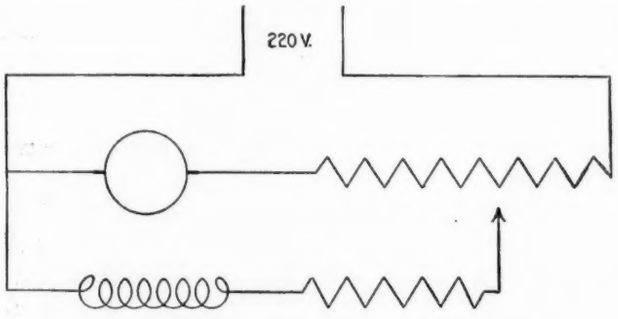


FIG. 1. RESISTANCE IN SERIES WITH SHUNT FIELD

compound-wound direct-current motor. Slight adjustments of speed may be made by shifting the brushes; movement in a direction against the rotation causing an increase in speed, and *vice versa*. It is better, however, to set the brushes for the best commutation and to secure the desired speed by other means.

An increase in speed may be accomplished by weakening the field magnetism, either by decreasing the field current by means of a rheostat in series with the shunt field or by increasing the reluctance of the magnetic circuit by increasing the air gap. The air gap may be increased either by boring out the field polepieces or by removing the shims under them, if there be any. Of the two methods, field control by series resistance is more easily arranged and is not a permanent change. However, it is generally possible to increase the speed only a limited amount in this manner, as sparking will result. About 15 per cent. increase is usually the maximum. Increasing the air gap is the better procedure from the point of view of commutation, as it reduces the effect of armature reaction and does not cause the ratio of armature to field ampere-turns to increase. The greater the ratio of armature to field ampere-turns, the more the tendency toward shifting of the magnetism under load, with consequent sparking. By increasing the air gap slightly, it is often possible to increase the speed of a motor 25 per cent. without serious commutation trouble; or a slight increase can be secured by chamfering the pole tips. The latter method tends, at the same time, to reduce armature reaction and to improve commutation at the higher rotation. In speeding up a motor, mechanical considerations must be borne in mind and too high peripheral speed avoided. Most motors will stand safely a 25 per cent. increase.

To decrease the speed of a shunt- or compound-wound motor the opposite procedure is followed. The air gap may be decreased by shimming the polepieces, or the current through the fields may be increased by reconnecting them in series-parallel and inserting a suitable rheostat. It may be impossible to greatly increase the field current without overheating the field windings. If the field iron is saturated, a large increase in field current will cause only a small reduction in speed. On the other hand, a decrease in the air gap may be undesirable, either because of the small mechanical clearance or because a narrow air gap increases the armature reaction effect.

In changing the speed of any motor, it must be remembered that the horsepower output is proportional to the torque and the speed. With a given torque the horsepower falls off as the speed decreases. If the load remains unchanged it is necessary that more torque be obtained at the lower speed. This requires more load current, accompanied by a greater heating tendency. At the same time the ventilation effect due to rotation is lessened. Hence, when the speed of a motor is decreased it cannot be expected to develop the same power that it would develop at rated rotation.

Where it is desired to utilize a motor for a speed appreciably higher or lower than rated, it becomes necessary to rewind the armature. The speed of a direct-current motor, other factors remaining unchanged, depends upon the number of turns in the individual armature coils. This is because sufficient counter electromotive force is generated at lower speed in the armature having more conductors in series. In order to adapt an 1800-r.p.m. motor for operation at 1200 r.p.m. it becomes necessary to rewind the armature with coils having 50 per cent. more turns of smaller wire. This relation holds for other changes of the same nature.

It is quite possible to utilize direct-current motors designed for one voltage upon another lower voltage, but not often possible to reverse the procedure without rewinding. If a 220-volt shunt-wound motor be connected just as it stands to a 110-volt circuit, the speed will not be reduced 50 per cent. as might be imagined. The reduction in voltage across the armature would cause this change if the field strength remained unchanged. The weakening of the field tends to maintain the motor speed; hence the resulting rotation may be 10 to 25 per cent. below that at 220 volts, depending upon the saturation of the fields and other design factors. Since the field is so weak at 110 volts the motor has little torque and displays poor speed regulation. It is much better to maintain the field strength by series-paralleling the

fields, thus maintaining the normal field current. If this is done the motor will operate at half the rated speed, afford good regulation, exert a torque about equivalent to its normal value and develop about half its rated power with normal heating. It is thus quite feasible, for emergency or temporary service, to utilize a 220-volt motor for 110-volt duty. In a similar manner a 500-volt motor can be used on a 220-volt circuit.

Sometimes the armatures of direct-current motors can be reconnected for half-voltage, connecting adjacent pairs of commutator bars together and paralleling the armature circuits connected to these bars. It is then usually necessary to increase the size of the brushes to carry the increased current attendant with the same rating at lowered voltage.

In placing a direct-current motor on a voltage materially higher than rated (unless the machine be rewound), it becomes necessary to insert resistance to reduce the effective voltage at the terminals. The resulting action is similar to that of a motor with armature control—the greater the load the lower the armature voltage and, consequently, the lower the speed. The speed regulation is poor. This effect is reduced, however, by the fact that, as the terminal voltage is decreased the field is weakened and a compensating tendency toward rising speed injected. The torque under heavy loads is low, inasmuch as the armature voltage is then small and, in addition, the field is weak. In proportioning the series resistance for this connection it is required to figure the drop necessary to bring the terminal voltage to rated value for one particular load. For lesser loads the terminal voltage will be high, for greater loads it will be low. If the motor be operated lightly loaded for long periods the field windings will be subjected to considerable over-voltage and will likely overheat.

An arrangement which will give better satisfaction is to place resistance in series with the shunt field, and this is tapped into the armature-circuit resistance at a point determined by experiment to render the best service (see Fig. 1). This prevents operation of the shunt fields upon heavy over-voltage. It maintains a fairly constant field strength and better torque under load, at the same time allowing the field to be weakened slightly under load in order to aid the speed regulation.

Alternating-Current Motors

The cases most likely to arise in connection with induction motors under modified service conditions are changes in voltage, speed, torque, frequency, phase or a combination of these.

The necessity of utilizing motors of one voltage for service upon lines of different voltage is, of course, often met by the use of transformers, but the extra expense of a transformer installation is often undesirable. The primary windings of induction motors are connected in various ways; delta, star, double-delta and double-star being the more common three-phase connections. To change the voltage rating these end connections need only be modified. It is an easy matter to reconnect a delta winding into a double-delta or *vice versa*. Likewise, a star winding can be readily changed to a double-star. If an induction motor has a double-delta or a double-star winding and is rated at 110 volts; then, if connected single-delta or single-star respectively, it will be correct for 220 volts. Similar relations exist for 220- and 440-volt windings. Figs. 2 to 5 show such connections and indicate the changes required.

Consider the case of a 220-volt motor wound single-delta, which it is desired to utilize upon a 440-volt circuit. There is only one possibility here—that of connecting to single-star. The winding would then normally require 380 volts (220×1.73) for equivalent operation. If this motor be placed on a 440-volt circuit an over-voltage of 15 per cent. will be impressed, with a resulting high core loss and lowered power factor. Increased core loss will cause the iron to heat. This may be allowable for emergency service, particularly if less than full load is carried. The core losses in an induction motor may be varied within rather wide limits without influencing the temperature of the windings more than a few degrees. Increasing the magnetic intensity means mainly an increase in the ratio of magnetizing current to full-load current. Since the magnetizing current is largely wattless, its relative increase causes a decrease in the power factor.

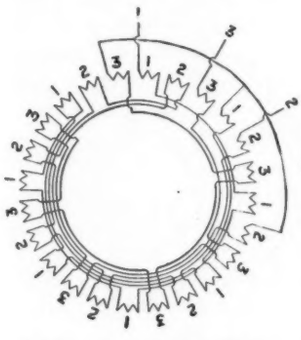


FIG. 2. SINGLE STAR

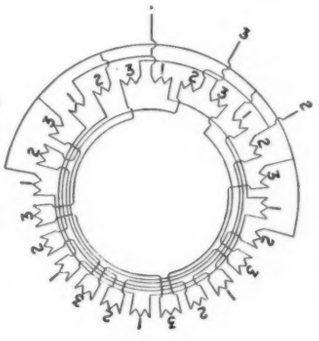


FIG. 3. DOUBLE STAR

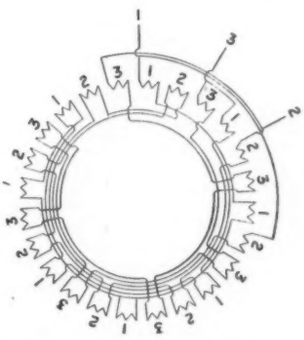


FIG. 4. SINGLE DELTA

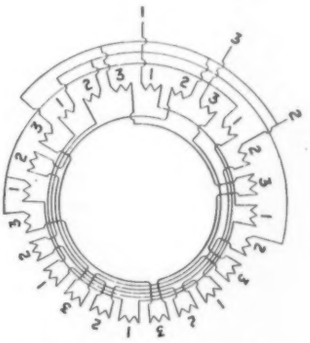


FIG. 5. DOUBLE DELTA

Next consider a six-pole three-phase motor having four coils per pole per phase, connected double-star for 220 volts, and let it be desired to operate upon a 110-volt circuit. There are here two possibilities. If the connections be changed from double-star to double-delta the normal voltage rating will be changed from 220 to 127 volts. Such a motor will operate fairly well upon 110 volts, but will be a little short of starting torque and pull-out torque. To overcome this one coil in each pole group could be cut out and dead-ended. This would reduce the voltage rating approximately one-sixth, making the normal rating 107 volts. Care must be taken to cut out symmetrical coils.

The second possibility for this case lies in making the circuits into a quadruple delta connection. There were already two parallel circuits in each phase, each circuit

including three pole groups. A quadruple winding would thus include the coils of 1½ pole groups in each of the four parallel circuits per phase. Thus each of these circuits would contain the four coils in one pole group and two coils from another pole group. In dividing the coils in a single group the two outer coils would be placed in one circuit and the two inner ones in the other circuit, thus retaining a symmetrical relation. Fig. 6 shows this connection.

Two-phase motors are connected with all the coils in one phase in series or with two or more sets of coils in parallel to make up the circuits for each phase. In many cases, where the pole groups permit, it is possible to reconnect the pole groups from series to parallel connection or *vice versa* to adapt a motor for lower or higher voltages.

The synchronous speed of an induction motor depends upon the number of poles per phase in the stator winding and the frequency of the circuit. The full-load speed depends upon these two factors and also upon the slip. Evidently, for a circuit of fixed frequency the only possible variables are the number of poles and the slip. Changing the number of poles in the stator is a means for securing rather wide changes of speed, while adjustment of the rotor slip can be used for comparatively small speed changes.

Motors can sometimes be reconnected in such a manner as to run at half-speed, by reversing the polarity of half the coils so that all the coils of each phase are of like polarity. This arrangement causes an equivalent number of consequent poles to occur at intermediate points, as shown in Figs. 7 and 8. Thus a stator wound for 4 poles per phase (1,800 r.p.m.), as shown in Fig. 7, is represented in Fig. 8 as reconnected for 900 r.p.m. It will have but half its original horsepower capacity at the reduced speed. It will be noted that, in reconnecting, the coils have been changed from parallel to series. This is because it is necessary to have twice as many in series for the low speed, since twice the turns are required to produce the proper counter-voltage. The arrangement suggested is that used for the familiar multispeed motors. For such usage it is necessary to bring out the coil ends to a controller and to complete the connections for either arrangement in the controller.

Induction motors can be reconnected in other ways to change their speeds, but their performance is nearly always adversely affected. For instance, a 220-volt, 1800-r.p.m. motor having 3 coils per pole and 4 poles per phase could be connected with 2 coils per pole and 6 poles per phase to rotate at 1200 r.p.m. The result would be a high no-load current, because, with the speed reduced, the number of series turns per phase should be proportionately increased to maintain the necessary counter-voltage. When reducing the speed a third the counter-voltage will be reduced a like amount. If the voltage impressed on each phase could be reduced the no-load current would be lessened. This could be done in case the motor was originally delta-connected, by changing over to star, thus reducing the impressed voltage per phase to 128 volts. The normal counter-voltage would have been reduced to about 145 volts by the reduction in speed, so that such an arrangement would work out fairly well. The reconnection of the coils without changing their throw introduces fractional pitch, causing higher saturation of portions of the magnetic circuit, requiring higher magnetizing current and lowering the power factor and efficiency.

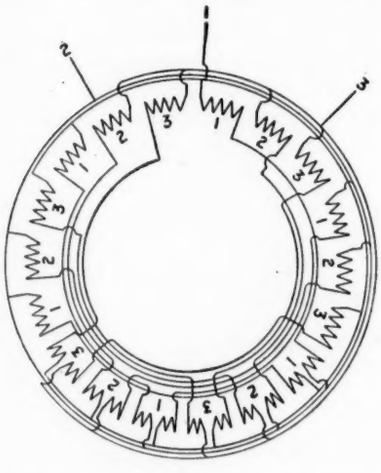


FIG. 6. QUADRUPLE DELTA CONNECTIONS; 6 POLES, 4 COILS PER POLE PER PHASE

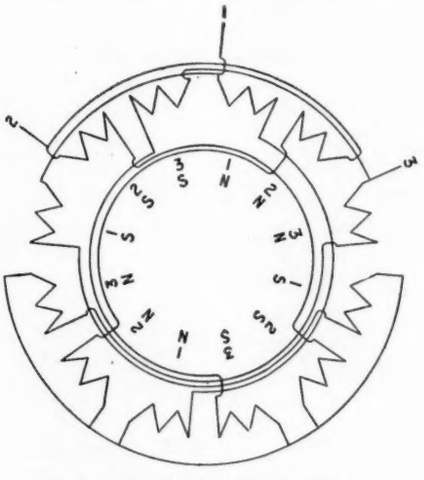


FIG. 7. DOUBLE STAR CONNECTIONS; 4 POLES PER PHASE GIVING NORMAL SPEED

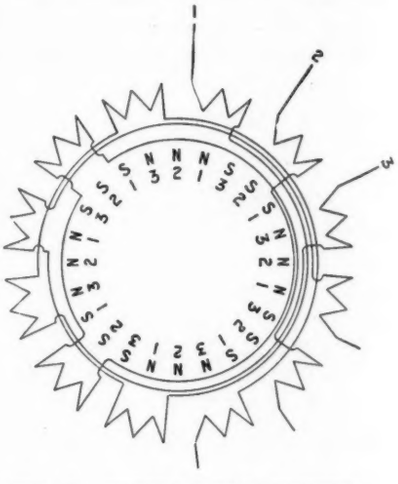


FIG. 8. SINGLE STAR CONNECTIONS FOR 8 POLES GIVING HALF SPEED

Another way in which speed changes can be accomplished is by changing the rotor slip. Any type of induction motor rotates at nearly synchronous speed at no load, but the higher the resistance in the rotor circuit the greater the slip, hence the lower the full-load and overload speeds. No matter how small the rotor resistance, it is impossible to exceed synchronous speed; but, by increasing the rotor resistance the full-load speed can be reduced perhaps 10 to 15 per cent. The speed regulation then becomes poor, however. More important than speed change is the effect of rotor resistance upon the torque and starting current. A high rotor resistance gives characteristics similar to a compound-wound direct-current motor. It has good starting torque with moderate starting current and good pulling power upon the peaks. High rotor resistance lowers the efficiency, since power is dissipated in the extra resistance. If the resistance is in the rotor itself the added losses will tend to cause considerable heating. Squirrel-cage motors having low rotor resistance can be changed for higher resistance characteristics by turning off, slotting or otherwise decreasing the cross-

section of the end connections. Soldered end connections will not ordinarily permit much reduction in their cross-section, since the increased heating will cause solder throwing. The newer welded end-rings are more dependable and will allow more manipulation.

Operating on Different Frequencies

Next consider the use of induction motors upon circuits of frequencies other than that for which they were designed. The two most common commercial frequencies are 60 and 25 cycles. The synchronous speed of an induction motor is determined by the number of poles and the frequency. A 60-cycle motor connected to a 25-cycle circuit will operate at a little less than half speed and will develop about half its rated horsepower. However, if the voltage be that at which the motor is rated for 60 cycles, an excessive current will flow. This is because the counter-voltage is proportional to the speed and upon 25 cycles it will be about half its 60-cycle value. In order that normal current may flow, the 60-cycle motor should be used upon a 25-cycle circuit of half-voltage or thereabouts. If the available voltage at 25 cycles is the same as the 60-cycle rated voltage then the motor may be reconnected for the higher voltage, as previously outlined.

It might be mentioned that a reduction in frequency is accompanied by diminishing core losses, tending to reduce the heating. This tendency is about offset by the fact that operation upon half-voltage is a little above the true ratio, 25 to 60. Also, the reduction in speed lessens the ventilation so that the losses must be lower if the same operating temperature is to be maintained.

The use of 25-cycle motors upon 60-cycle circuits is the reverse of the condition just discussed. The 25-cycle motor will run at approximately twice its rated speed upon a 60-cycle circuit; it will develop twice the rated horsepower and must either be used upon a circuit of double the rated voltage or be reconnected with parallel circuits to enable its use upon rated voltage.

Use on Systems of Different Phase

When a polyphase induction motor is in rotation, all the phases but one may be disconnected, and the motor will continue to operate with nearly the same characteristics as it had with all phases connected, except that its capacity is reduced about one-third. Any two-phase or three-phase induction motor can thus be used on a single-phase line provided some means is arranged to start it. Some manufacturers sell standard three-phase motors provided with a split-phase starting box for single-phase service. This does not secure very heavy starting torque.

It remains to consider the use of three-phase motors upon two-phase circuits and *vice versa*. Perhaps the most common method of accomplishing this is by the use of transformers, Scott-connected. This is the most practical way where an entire plant having motors of one type is to be connected to power lines of different phase relations, or where an isolated plant uses central-station service of different phase in case of breakdown. But in the case of individual motors changes can sometimes be made in the end connections to serve the purpose without the addition of external phase-changing apparatus. The end connections of a three-phase motor can be entirely disconnected and the coils reconnected for two-phase, or the Scott connection can be applied to the motor windings themselves.

We will follow through the work of reconnecting a three-phase 440-volt 36-coil single star-connected motor to operate upon a two-phase 440-volt circuit. When operating three-phase this motor had 12 coils per phase in series. The voltage per phase from line to neutral was $440 \div 1.73 = 254$ volts, and the voltage per coil was $254 \div 12 = 21.1$ volts. Reconnecting for two-phase would give 18 coils in series per phase. Placing this winding upon a 440-volt circuit would make about 24.4 volts per coil, an excess of 3.3 volts, or 15 per cent. This increase in voltage per coil will cause higher saturation of the iron, will increase the pull-out torque, cause a greater no-load current and lower the efficiency and power factor. In general, 10 per cent. is the greatest advisable increase in voltage. Moreover, in two-phase motors having more coils per pole per phase the coils span a greater arc and the individual coil voltages are further out of phase with each other than for a three-phase winding. For this reason the excess of 15 per cent. just figured would more likely be 20 or 25 per cent. It is thus seen to be difficult to reconnect a three-phase motor for two phases without rewinding, since the resultant normal voltage is incorrect for a standard circuit. As a rule about 25 per cent. more turns are required in the winding

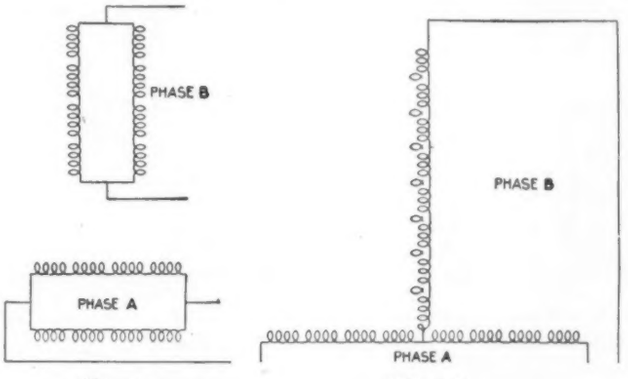


FIG. 9-a FIG. 9-b

Fig. 9-a. Original Two-Phase Connections. Fig. 9-b. Connections Changed for Three-Phase Operation

of a motor to be operated upon a two-phase circuit of the same voltage, saturation and other characteristics remaining the same. About the only satisfactory way is to rewind the motor with coils of 1¼ times as many turns per coil.

It is somewhat easier to adapt a two-phase motor for use on a three-phase circuit. The two-phase winding will have an excess of turns per phase, which difficulty can be overcome by dead-ending about 20 per cent. of the coils. symmetrically located, and thus obtaining the proper voltage.

Connecting the coils of a motor on the principle of the Scott connection, will be illustrated by taking the case of a two-phase, 220-volt motor having 8 poles and 6 coils per pole per phase. The original two-phase connection was for 220 volts and the coils were grouped in parallel circuits of 4 coil groups each, see Fig. 9-a. To adapt the motor for a three-phase line the two phases were "T" connected as shown in Fig. 9-b. All the coils in each phase were placed in series to secure a 440-volt rating with the new connection. To approximate the true triangular values of three-phase voltage it was necessary to reduce the number of turns in phase *B* to about 86 per cent. of those in phase *A*. This was done by cutting out

and dead-ending one symmetrically located coil in each of the groups in this phase. The turns of this phase were thus reduced 15 per cent., a sufficiently close approximation. The Scott connection is superior to any other method of two-phase and three-phase interchange, but it is possible only when the winding permits the omission of symmetrically located coils in one of the phases to secure the 86 per cent. relation of voltages.

Foundation Bolts for Steel Chimneys

By H. D. Hess*

As the rules suggested by engineers for the sizes of foundation bolts for chimneys vary widely, the following table has been compiled to compare this practice. The first six chimneys are described in a published pamphlet and are said to have been built. The remainder have been built and are standing. Of the numerous formulas the two extreme ones may be put in the form,

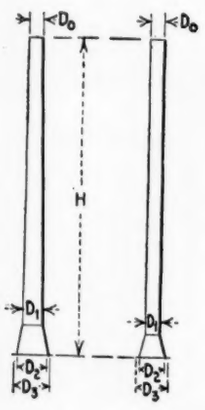


Fig. 1

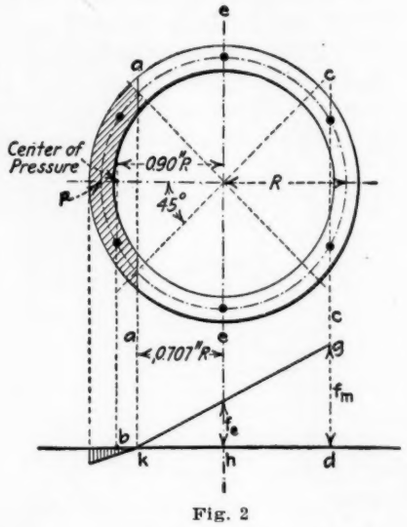


Fig. 2

OUTLINE OF CHIMNEY AND STRESS DIAGRAM FOR FOUNDATION BOLTS

$$f_m = \frac{M}{k \times N \times a \times R}$$

in which,

M = Moment tending to overturn the chimney, in foot-pounds;

N = Number of foundation bolts;

a = Minimum area of a bolt, usually at the root of the thread;

R = Radius of the bolt circle in feet;

f_m = Maximum fiber-stress in any bolt in pounds per square inch.

The value k varies with the different conditions and is given later.

If we assume the nuts brought to a bearing, with practically no initial stress and no wind acting, the center of pressure between the chimney and the foundation will coincide with the center of the bolt circle. If the wind now acts from the right the center of pressure will move toward the left, and at the extreme position it will approach the point p on the bolt circle. The formula giving the lowest stresses assumes this concentration at the point p and further assumes the fiber stresses in the bolts proportional to their distances from a tangent through the point p. The value k is then 0.75 in the equation just given, and M is the wind moment less the righting moment. The latter is taken as the weight of the chimney in pounds times R.

In the formula giving the highest stresses the chimney is assumed as fixed at the base, the neutral axis being taken as e-e. If the bolts on both sides of e-e are effective they must resist compression, a condition here impossible of realization. When the formula is solved in this way k is approximately 0.50 and M is the full wind moment.

DESIGN DATA FOR STEEL CHIMNEYS

Designation	Chimney Diameters: Top D_0 Ft.	In.	Base D_1 Ft.	In.	Bell Base D_2 Ft.	In.	Bolt Circle D_3 Ft.	In.	Ht. of Chimney, H, Ft.	Wt. of Steel, Tons	Net Overturning Moment, Ft.-Lb.	Foundation Bolts: No.	Diam. In.	Maximum Fiber Stress f_m Lb. per Sq. In.
1	3	4	4	6	7	0	7	6	70	7.1	228,400	6	1	11,700
10	4	4	5	6	8	9	9	3	90	12.3	492,100	6	1¼	15,200
20	5	10	7	8	12	0	12	6	125	24.7	1,281,270	8	2¼	12,700
30	7	4	9	6	15	9	16	3	175	45.0	3,183,165	10	2¾	17,500
38	9	10	12	0	18	6	19	0	190	64.3	4,706,540	12	2¾	16,600
45	11	10	14	8	25	0	25	6	300	143.7	14,218,000	16	2¾	28,000
B	4	9	....		....		6	5	100	8.3	664,900	4	2¾	20,080
D	6	0	....		9	6	9	10¾	125	16.0	1,263,700	4	2	41,400
E	6	6	....		9	0	9	4	120	15.3	1,276,400	4	2¼	27,500
F	8	0	....		11	3	11	7½	120	....	1,538,200	4	3	18,400
G	10	0	....		14	0	14	6	146	30.8	2,795,460	6	2¾	25,900
K	16	0	....		....		27	0	225	77.0	10,278,900	12	3	17,600
L	11	6	....		....		18	0	200	55.0	4,859,000	8	3½	15,550
M	30	9½	....		....		51	0	400	438.0	41,518,300	36	4	6,780
R	8	0	12	4	....		21	1	217	65.0	4,683,800	12	2¾	11,950

A comparison of the data given in the accompanying table indicates that few of the 15 chimneys had been designed on either basis. It seems to the writer that a basis nearer the truth might be had by assuming in the extreme position one-quarter of the chimney base in contact with the foundation, as shown in Fig. 2 by the shaded portion. The neutral axis is a-a. The bolts to the right of a-a are stressed proportionally to their distances from a-a. The figure also shows the stresses in the concrete. The moment due to any bolt will be the product of its area, fiber-stress and the arm from the bolt center to a line through the center of pressure and parallel to a-a. In this case the value of k is 0.67. The overturning moment is here the wind moment about the base less $W \times 0.9R$. In all cases the wind moment equals the wind force on the chimney times the distance from the base of the chimney to the center of pressure of the wind force. For a cylindrical chimney this equals $\frac{D_1 \times H^2 \times w}{2}$ foot-pounds, where w, the wind pressure per sq.ft. of projected area of the chimney, is usually assumed at 25 to 30 pounds. D_1 and H are measured in feet. The working fiber stress may be taken from 12,000 to 16,000 lb. per sq.in. The maximum calculated fiber-stresses based on a wind pressure of 30 lb. are given in the right-hand column of the table.

A Connection to the Atmosphere should always be made beyond the oil extractor on exhaust pipes so that the oil will not be blown into the atmosphere with the exhaust steam.

The Natural Gas Production in 1914, according to a report of the United States Geological Survey, was 591,866,733,000 cu.ft., which at 15.9c. per thousand represented a value of over ninety-four million dollars. West Virginia led with approximately four-tenths the total production, followed by Pennsylvania, Ohio, Oklahoma and Kansas in the order named. Iowa, with 200,000 cu.ft., produced the least of any of the natural gas states.

*Professor of Machine Design, Cornell University.

Fisk St. Station Economizers

By Thomas Wilson

SYNOPSIS—Economizers arranged on the unit plan, one for each boiler. Feed water raised from 110 to 280 deg. F., and flue gases reduced in temperature from 600 to 300 deg.

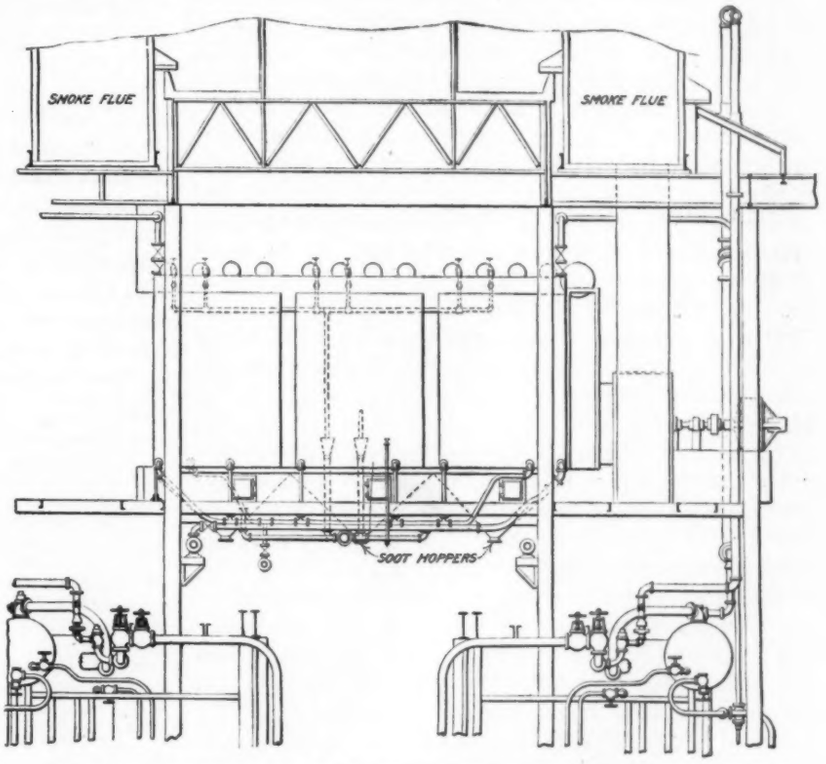
The principal objection to the economizer has been the drop produced in draft between stack and boiler. Its use was therefore limited to a natural-draft plant having an exceptionally high stack, or to a plant equipped with induced or forced draft, and even here, due to a number of conditions, its maximum possibilities were greatly curtailed. It is common practice for one economizer to serve a number of boilers, or perhaps the entire installation. A bypass is usually provided so that the gases may flow directly to the stack in case of necessity; but when this condition arises the service of the economizer is lost to the entire number of boilers. The drop in draft is considerable if the economizer is long, and, depending on the layout, its use generally increased the travel of the gases. The number of dampers employed is frequently excessive, resulting in a further loss; and with the brick setting commonly used radiation and air infiltration are additional factors tending to reduce the economy.

With boilers operating at a low rate of evaporation, so that the temperature of the flue gases is comparatively low, and with enough exhaust steam from the auxiliaries to raise the temperature of the feed water to 200 deg., the work remaining to the economizer is so limited that the gain effected is in many cases neutralized by the inherent disadvantages. This is particularly true when the incoming water is permitted to find its own way through the economizer, as is the case where all the sections are connected in parallel.

The installation of large generating units turning out current at high efficiency has caused indirectly a radical change in economizer design. To obtain the highest economy these immense units are supplied with steam by large boilers operating at high pressure and during the peak at a high rate of evaporation. Naturally the temperature of the flue gases is high, and with a water rate of 11 to 12 lb. per kw.-hr. for the main units economy dictates the use of motor-driven auxiliaries. The temperature corresponding to a vacuum of 29 in. is 79 deg. F., and with only a small amount of exhaust steam to raise the temperature of the condensate for boiler feeding the work for the economizer is increased, and as a result a larger saving is possible.

Fisk St. Station of the Commonwealth Edison Co. of Chicago was the first large plant in this country to adopt the fuel economizer designed on the unit plan, one for each boiler, and with direct passage to the smoke flue. These economizers were installed in connection with the latest addition to the plant, which was described in *Power* of Nov. 4 and Nov. 11, 1913. They have been in operation a little over a year, although first conceived about three years ago, and subsequently the same unit design has been applied to quite a number of smaller plants.

With the new unit system the economizer is nothing more than an addition to the heating surface of the boiler. In fact it is an integral part of each boiler, although at Fisk St. provisions have been made to bypass the gases and cut out the economizer should this be necessary. Ample gas passages reduce the drop between the boiler and the stack, and the desired intensity of draft is maintained by an induced-draft fan located between the economizer and the smoke flue. The fan runs at practically constant speed, and the draft is under damper control. A metal-asbestos casing reduces radiation and eliminates air leakage. Metal-to-metal joints in the economizer safely withstand the high operating pressure. Connections between headers are so made that the water is given a positive flow up one group of sections, down another, and so on. In this way its velocity is greater and the temperature more uniform than with the usual method of allowing it to select its own passage through the various sections. By reducing the width of the sections as the gas becomes cooler in its passage to the smoke flue a relatively uniform and high gas velocity is maintained by the fan. A third factor having an im-



SHOWING LOCATION OF THE ECONOMIZERS ABOVE AND BETWEEN THE BOILERS

portant bearing on economizer efficiency is the mean temperature head. In the plant under discussion this is above the average, so that conditions are favorable for a high-heat transfer between gas and water.

As may be determined from the previously published descriptions, each of the large turbine units is served by four boilers extending in line across the boiler room. The two rows of four each are placed back to back. As the vertical uptakes are just behind the front drums of the boilers, there is plenty of room for the Sturtevant economizers between them, as shown in the accompanying drawing. With this arrangement the gases from one boiler may pass through the economizer and up to the smoke flue on the opposite side, or directly up to the smoke flue on the same side, if it is desired to cut out the economizer.

Each boiler has 12,200 sq.ft. of heating surface and 2323 sq.ft. of additional surface for superheating. The design calls for a normal evaporation of 80,000 lb. of water per hr. and a superheat of 225 deg. at the boiler. The maximum working pressure is 225 lb.; but under normal operation the pressure is 215-lb. gage. The economizer has 528 tubes, 12 ft. high, having external diameters of $4\frac{9}{16}$ in. and $\frac{3}{8}$ in. of metal. The working surface, including the exposed surface of headers, totals 8500 sq.ft., which is practically 70 per cent. of the steam-making surface. The economizer is divided into three divisions, each containing 16 sections. In the first division, where the gases are hottest and have the greatest volume, the sections are 12 tubes wide; in the second, 11 tubes, and in the third, 10 tubes wide. In staggered rows the tubes are spaced on 8-in. centers crosswise and $7\frac{1}{4}$ in. apart along the run. The free areas of the three divisions are 48, 44 and 40 sq.ft. respectively. These areas are figured to correspond approximately to the reduction in volume of the gas as it cools on its way through the economizer. Thus the gases are maintained at a uniform velocity by the fan, which has a rated capacity of 80,000 cu.ft. per min. of gas at 300 deg. F., and will maintain a draft of $1\frac{1}{2}$ in. at the boiler uptake. The maximum gas velocity through the economizer is close to 2000 ft. per min. The fan is driven at 290 r.p.m. by a 75-hp. three-phase induction motor. Magnesia blocks 4 in. thick between steel plates form the casings for the economizers and reduce radiation and air infiltration to a minimum.

A feature of interest is the removal of the soot. From the action of the scrapers on the tubes the soot falls into hoppers, one below each section of the economizer. By means of a double Y fitting, pipes from these hoppers combine into a common 4-in. pipe leading down to the ashpit under the boiler. A special steam nozzle at the turn into the setting draws the soot from the economizer and expels it into the ashpit.

In each division of the economizer the water passes up through the first eight sections, down through the next four and up through the last four. The flow is positive, and with the boilers operating normally the average velocity will approximate 6 ft. per min. in the four-section groups and 3 ft. per min. through the eight sections, the average reducing to $4\frac{1}{2}$ ft. per min. The water-holding capacity of the economizer is 41,000 lb.

Although most of the auxiliaries are motor-driven, due to the exceptionally low water rate of the turbines, some exhaust steam is available for heating the feed water. For the boilers supplying the 20,000-kw. General Electric unit there are two turbine-driven feed pumps, and the dry-vacuum pump for the same unit is of the reciprocating angle type. The condensate has a temperature of 70 deg. F. In an open heater the temperature is raised to 110 deg. by the exhaust from these auxiliaries.

The condenser of the 25,000-kw. Parsons turbine is served by a kinetic air ejector which employs a steam ejector to augment the vacuum, and this steam raises somewhat the temperature of the condensate in its passage to the kinetic tank. Another section of the tank acts as a feed-water heater and may receive exhaust from the only steam-using auxiliary of this unit, one of the boiler-feed pumps. In cold weather a small amount of steam is bled into this heater from an intermediate stage of the turbine. In either case, then, the temperature of the condensate is raised a few degrees. Operating data at the plant show that the feed water has an average temperature of 110 deg. when it reaches the economizer and passes out at a temperature of 280 deg. The flue gases enter at 600 deg. and discharge to the stack at 300.

Question of Validity of Anti-Smoke Ordinance

By A. L. H. Street

A municipal ordinance penalizing the emission of dense smoke from a power plant, locomotive, or steamboat is unenforceable, so far as the smoke cannot be prevented by known appliances. This is the gist of a decision recently announced by the Michigan Supreme Court in the case of People vs. Detroit, Belle Isle & Windsor Ferry Co. (153 Northwestern Reporter, 799). The decision reverses a conviction of the defendant on the charge of violating the following provisions of a Detroit ordinance:

> That the emission of dense black or gray smoke from any smokestack or chimney used in connection with any steam boiler, locomotive or furnace of any description, in any apartment house, building, boat or any other structure, or in any building used as a factory, or for any purpose of trade, or for any other purpose whatever within the corporate limits of the city of Detroit, shall be a public nuisance per se.
>
> The owner or owners of any locomotive, engine, steamboat, tug, dredge, or pile-driver, and the general manager, superintendent, yardmaster, engineer, fireman or other officer or employee having in charge or control the operation of any locomotive, engine, steamboat, tug, dredge, or pile-driver, within the corporate limits of the city of Detroit, who shall cause, permit or allow such dense black or gray smoke to be emitted therefrom within said corporate limits, shall be deemed guilty of creating a public nuisance and of violating the provisions of this ordinance.

The opinion of the Michigan court does not declare the ordinance to be void, but holds that it is inapplicable to marine practices, and will remain so until invention of a new device which will prove efficient. And it is further decided that the holding of the court is not to be construed as preventing liability as for the creation of a common-law nuisance when the facts of a particular case bring it within common-law principles. The gist of the opinion is that the ordinance must not be interpreted as applying to vessels. Referring to the testimony of experts on the subject the Supreme Court says:

> The expert testimony introduced upon the question, while not conclusive, strongly persuades us to the view that up to the present time no device has been invented which within the confined space available for installation in marine practice is adequate for the elimination of smoke so long as the consumption of bituminous coal is permitted.

The court adds that the fire tugs belonging to the city are not equipped with any smoke-consuming device.

Notes on Overhauling the Ammonia Compressor

By F. E. Matthews

SYNOPSIS—Duplicate machines for emergency use sometimes foster negligence. The article treats generally of the many things that must be considered and attended to when ready to overhaul the ammonia compressor.

The rapidly growing application of mechanical refrigeration to new, as well as old, processes may explain, if not excuse, to some of the more experienced engineers, the frequent consideration of the almost self-evident principles involved in the operation of refrigerating machinery.

It seems superfluous to suggest that a refrigerating plant should not be started at the beginning of a season without first determining that it is in condition, not only to begin, but to efficiently carry out its functions under conditions of constant operation for considerable time.

Duplicate machines are an insurance against shutdowns, but it seems that the plants where breakdowns are the most costly are those where duplicate units are provided. This condition is so common that one may well question the advisability of making the additional investment entailed by duplicating machinery until convinced that there is need for this expensive kind of insurance. Necessity is the mother of more than invention, and the engineer who has to keep his plant in operation because there are no duplicate units to fall back on usually learns to do it, though sometimes not without a few disconcerting experiences.

The wrecking of a machine, especially an ammonia or other gaseous refrigerant compressor, may occur through the failure of a small, as well as a large, part—through the failure of a valve stem or a connecting-rod bolt, as well as that of a crankshaft or a connecting-rod. The failure of these parts may be caused by crystallization, as well as by wear. The former is less common than the latter, which can be easily detected and remedied if advantage be taken of the season in which the machine can be most advantageously stripped, inspected and repaired.

A well-constructed machine will stand an unreasonable amount of abuse for a short time, but once a year is not too often to favor it with a thorough overhauling. In large compression refrigerating plants where there are no duplicate units and—one may almost assert—consequently no breakdowns, this is effected by completely stripping and reassembling the compressors every winter. In many places where unusually large units are employed, this work on a certain machine is done by the engineers operating that machine. The advantages of this system are almost too obvious to mention. Each engineer seeks to have his machine or machines operate more smoothly and continuously than his neighbor's, and when overhauling time comes not a part escapes the most careful inspection and repair. It must be remembered that the year has 365 days, each of which has 1440 minutes in which the machine, if it is earning its full keep, will be required to make a great number of revolutions.

In the case of an engineer having only one refrigerating machine under his care, there cannot be the same keen interest, due to emulation, which stimulates his brothers operating large units side by side. He may, however, set himself the task of seeing that his plant as a whole is more efficiently operated than those near him, or—although it partakes somewhat of the nature of playing chess with oneself—he may determine that his plant shall operate more efficiently this year than it did last.

When the various parts of the plant come up for inspection, each detail should be given the attention merited by the importance of its respective functions. Power is exerted on the crankshaft for the purpose of performing work on a gas. If the main crank bearings, for example, are not in condition to operate for a year without repair, the fact that the compressor proper is in first-class physical condition will be of no advantage during the time of shutdown.

Troubles of the Stuffing-Box

The stuffing-box and packing is for the obvious purpose of preventing the escape of the refrigerant into the engine room. Does it do it? If not, why not? If it is unusually difficult to keep the rod from "stinking," and it is found not to be caused by too wide variations in rod temperatures, which are due to the varying temperature of the incoming refrigerant and to friction, it is possible that the rod is not traveling coaxially with the cylinder. The crosshead shoes may be so adjusted that the crank end of the rod may be higher or lower than the head end. With adjustable pistons, the bull-ring studs may be so set as to displace the head end of the rod out of the axial line of the cylinder. Where solid pistons are used the displacement through wear is downward. If it is only slight the crosshead end of the piston may also be displaced an equal amount downward, under which conditions the rod, although not coaxial with the stuffing-box, will travel on its own axis, that is, parallel to the stuffing-box. Under this condition it is evident that the packing, in adjusting itself to the new position of the rod, will assume the form of an eccentric instead of that of a cylinder. If one end only of the rod is displaced in any direction, or both ends displaced but not in the same direction, the rod will have a certain amount of lateral motion as it passes through the stuffing-box. To satisfy a condition of tightness, this requires that the eccentricity of the packing change during every stroke. Even this unmechanical condition can be met with soft packings if the transverse travel of the rod is not too great. But under these conditions it would be practically impossible to maintain a tight rod with metallic packing. This is not an argument against metallic packing. That kind is employed to reduce friction, and its satisfactory use is an indication that no serious amount of friction exists. In the case of soft packing around a rod out of alignment, tightness is bought at the price of excessive friction because of the pressure that must be maintained on it to insure its changing form at every stroke without allowing the refrigerant to escape.

Is the compressor alignment sufficiently accurate to allow the use of metallic packing? If not, money is being spent, not only for packing, but also for power to overcome excessive piston-rod friction. This is not only a direct loss, but by producing heat it causes a double loss through heating the surrounding refrigerant, causing the latter to expand so that fewer pounds will find admission to the cylinder per stroke, proportionately reducing the capacity of the machine. See that the compressor is in alignment when it is started after overhauling. It should still be in alignment after it has been operated sufficiently long to allow the various parts subjected to heating to expand to their normal running condition. In case of large units the final adjustment of foundation bolts is sometimes left until this condition is reached.

Concerning Insulation

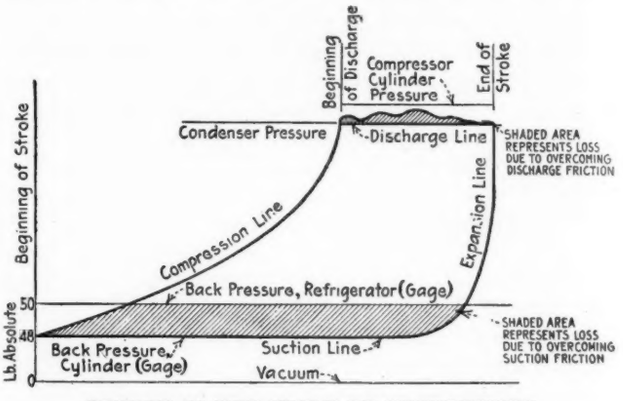
The function of the ammonia compressor is to trap a cylinderful of ammonia gas at the pressure and temperature at which it is evaporated in the refrigerator and compress it to such a pressure that it will pass into the condenser against the pressure therein. But this is often inefficiently performed. The inferior quality or absence of insulation on the pipes carrying the return gas from the refrigerators to the compressor is often responsible for the absorption of sufficient heat by the ammonia to increase its temperature materially above that corresponding to the pressure at which it is evaporated in the refrigerator. At an increased temperature and under the same pressure, a given weight of ammonia occupies an increased volume, consequently the absorption of heat by the saturated gas, resulting in superheating, causes less ammonia to be admitted to the cylinder. The further absorption of heat from contact with the heated compressor suction valves has a like effect.

The remedy is to effectively insulate the return lines with not less than 4 in. of hair-felt or cork covering, care being taken to see that all joints are carefully sealed and that the whole is thoroughly waterproofed. For no logical reason some architects and engineers often specify a much thinner insulation on the ammonia pipes than is used on the refrigerators. The contrary should be done, because the ammonia inside the pipes is colder than the air inside the refrigerators and because the pipes run through the usually hot engine rooms in which the surrounding air is of much higher temperature than that surrounding the refrigerator walls. The thickness of the insulation should be increased at least in direct proportion to the increased difference in temperature between the ammonia and the air surrounding the piping. Proper insulation on the return lines will largely correct the first loss. The second, resulting from the heat absorbed at the suction valves, is less easily remedied. Superheating and the consequent rarefaction of the gas may be prevented by carrying the frost line back to the compressor.

Adjusting the Valve Springs

The adjustment of the springs of the suction valves is often such that the pressure within the cylinder is materially lower than that in the pipes of the refrigerator or cooler. As the weight per cubic foot of the gas decreases with the pressure, and as the refrigerating effect depends on the weight of liquid evaporated, this decrease in pressure due to overcoming the resistance offered by the suction valves, and that of friction in the return line itself between the refrigerator and the compressor, results in a loss of capacity proportional to the reduction in absolute pressures. If, for example, the back-pressure (gage) in the pipes of the refrigerator is 35 lb. (35 + 15 = 50 lb. abs.) and that in the compressor cylinder is 33 lb. (33 + 15 = 48 lb. abs.), as might readily occur, the loss in refrigerating capacity from this cause would be 50 — 48 = 2 parts in 50, or 4 per cent.

If the suction lines are too small or contain too many sharp turns, replace them with larger ones using sweep ells or long bends. Adjust the suction-valve springs so that they will just close the valves in case they are located in housings forming a part of the cylinder, and so they will just balance the weight of the valves in case they are in the piston and operate vertically. Spring tension is not necessary for closing the valves in the latter case, as this function is performed by inertia, but rather to prevent their too rapid closing. Be sure that when these valves close, they close tightly. This means that each season they should be ground in. If the valves and seats are



EFFECT IN THE CYCLE OF COMPRESSION

in good condition, a few minutes' work with flour of emery and oil will suffice. If they are not, coarse emery first and emery flour later will be necessary. As in the case of any other valve, the grinding should continue with the valve stem in its working position until a bearing all the way around is obtained.

Attention to the Ammonia Cylinder Walls

The pistons and piston rings and cylinders should receive the same treatment as is customarily given to steam cylinders, bearing in mind that a refrigerating process is more expensive than that of producing power, that a given slippage of the ammonia past the compressor piston results in a greater actual loss than the escape of steam past an engine piston, and that, to make matters worse, ammonia is able to escape through a given opening faster than steam. Piston rings may be expanded by peening as is done with steam piston rings, but for the reasons mentioned unusual care should be employed in fitting them.

The discharge valves should receive the same careful attention given the suction valves. The loss because of too heavy springs on the discharge valves is due only to the increased power required to produce the higher discharge pressure necessary to overcome them. Their use does not occasion a loss of refrigerating capacity in the same way as with suction valves, for the difference in pressure required to open them comes, not at the beginning of stroke as with the suction valves, or even at the

end of the stroke, but at a point somewhere between, depending on the condenser pressure. These valves being open at the end of the compression stroke, the pressures in the discharge line and in the compressor cylinder will be balanced. The slight excess pressure, if any, required to keep the valve open produces a loss only because the residual gas, being at a higher pressure, will expand to a larger volume behind the receding piston and debar the entrance of the low-pressure cold gas during a slightly greater part of the suction stroke.

Most ammonia-compressor indicator diagrams show a decided reduction in discharge pressure as the piston nears the end of the discharge stroke. It would seem reasonable to suppose that, since the volume of gas discharged is small on account of the reduction of speed of the piston as it nears the end of the compression stroke, the pressures may equalize while the discharge valve is closing. So, while the discharge valve springs should not be stiffer than necessary to insure quick closing, there is a loss in refrigerating capacity incident to the use of too stiff springs.

Clearance in the Ammonia Cylinder

Unless the clearance between the compressor piston and the heads at each end is known, occasion should be taken during repair time to ascertain it. It may be determined in fractions of a lineal inch by inserting a piece of soft solder wire between the piston and the head so that it will be flattened as the compressor passes center. The amount of clearance is then found by a micrometer. This thickness of the flattened wire expressed in fractions of an inch, divided by the stroke in inches gives per cent. of clearance. If the volume of the clearance space is to be determined, the machine is turned over so that the piston stands at the end of the stroke and the space up to the discharge valve, which should be set in position in its seat, filled with oil. As a check the oil should be measured both as it goes in and as it is drawn out of the cylinder. The volume in cubic inches divided by the apparent cubical displacement of the compressor gives as a result the per cent. of clearance.

In double-acting machines the piston may be so set that the piston practically touches the crank end piston head. In fact it could be set so as to just touch if it could be known that the piston-rod temperature might not be reduced materially below that at the time of adjustment. On account of expansion from packing friction on the rod, it is needless to say, slightly more clearance must be left on the head than on the crank end. In the case of single-acting compressors, the pistons may be set to nearly touch the safety heads.

System's Capacity Depends on Compressor

In overhauling the compressor it should be remembered that, while other parts of the system may occasion certain losses in capacity through their inefficiency, the amount of refrigerating duty performed depends directly on the number of pounds of ammonia put through the cycle of evaporation and condensation, and that the compressor is the only organ for causing the refrigerant to traverse that cycle, and that, unlike the other parts of the system, the capacity of the system as a whole decreases practically in the same ratio as that of the compressor.

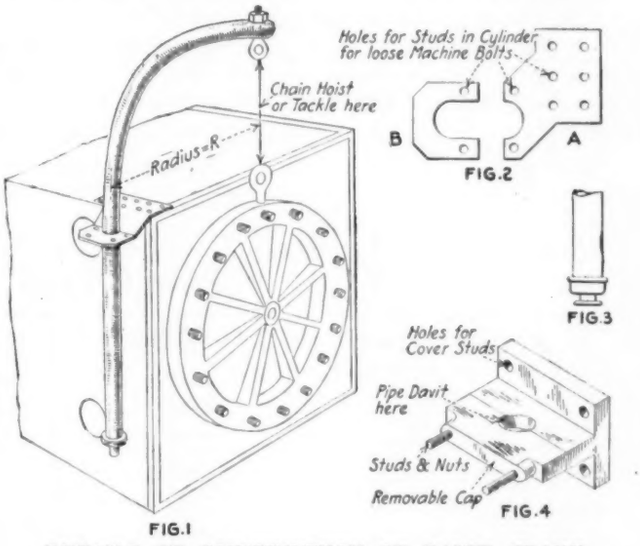
Accurate memoranda regarding clearance and important changes in adjustment should be kept for reference when the machine is put in operation. Likewise, records should be made of abnormal behavior of any part of the machine for reference when dismantled for repairs. Many hypotheses of what is going on inside the cylinder under operating conditions may be thus either proved or disproved by a careful examination of the parts during the dismantling process.

A Cylinder-Head Davit Crane

By F. W. Salmon

Cylinder heads are often handled by "main strength and awkwardness," endangering the men and the machinery. Engineers will tell you in great detail how they intended to "get rigged up" for such work, but good intentions are not sufficient—they should be executed promptly. The cost and the details of a simple crane that has proven cheap and satisfactory are given.

Assuming that the largest cylinder head in the plant is on a 32-in. Corliss, a crane for this size can be used on the smaller engines and will suffice for the whole plant.



DETAILS OF CONSTRUCTION OF DAVIT CRANE

The probable weight of such a head is 1100 lb., but to be on the safe side we will call it 1200.

A chain hoist of 2000-lb. capacity may be expected to weigh about 75 lb., and to raise 2000 lb. it will require a chain pull of about 75 lb. when hoisting the largest cylinder head. Adding about one-half of the weight of the horizontal arm, say 50 lb., we may call the effective weight at the end of the davit

$$1200 + 75 + 75 + 50 = 1400\ lb.$$

The davit may be mounted in several ways. Two of the best, or most generally useful, are shown. For the upper support shown in Fig. 2, ⅜-in. boiler-plate will answer well, fastened to the cylinder with ¾-in. studs and nuts to prevent leaks. The piece *B* should be secured with two ¾-in. machine bolts, and always kept in place on the cylinder, so that it can be found when needed. It is important to make the lower end, or step, of the davit mast, for a large engine, in the way shown in Fig. 3, to fit neatly over a stud an inch or more in diameter, so as to reduce the friction surface to a small radius, and so that the davit may be easily revolved, and may be steady and stand plumb. Another form of upper bearing, shown in Fig. 4, is made of cast iron, to go in the place of the valve cover

(on a Corliss engine) when needed and at other times tied to the davit and laid away.

If the davit is to be used upon several engines, it will probably be necessary to make the upper bearings (Figs. 2 or 4) of different offsets, so that the chain-tackle may hang exactly over the center of the cylinder head when the latter is in place, thus making it easy to swing the head on and off without injuring the threads on the studs.

Care should be taken not to build the davit out of short pieces of pipe, for threading a pipe materially weakens it. It should be made of one good piece. Such a crane without the chain hoist will weigh about 125 lb., can be easily handled by one man, and the cost is low. In one case the writer knows of, the material, with upper bearing like Fig. 2 cost $5, with an eye-bolt and three plates like *A* for three engines (the same plate *B* being used on all three). The engineer and fireman bent the pipe and drilled and tapped the holes during spare moments while on watch, thus making the complete davit cost only $1.65 per engine. Probably some reader can do even better.

Log Sheets at Delray Station

By Norman G. Reinecker*

SYNOPSIS—Operating log sheets covering every department of the plant. Detecting leakage of cooling water into steam space of condenser. Coal and ash sampling and analysis.

Records of the operation of the plant are kept carefully and thoroughly. There is a separate log sheet for each switchboard gallery, boiler room, engine room, condenser room and screen house. The observations recorded on these sheets are taken by the operators themselves at intervals of thirty minutes or an hour, as the case may be. Fig. 1 shows some of these log sheets with the data as actually taken for Wednesday, Dec. 9, 1914. All of the sheets are of standard size, 8½x11 in., and are printed on stiff cards to facilitate filing.

Form 654D-300-8-7-14

THE EDISON ILLUMINATING CO.
DETROIT, MICH.

DELRAY POWER HOUSE No. 1 & 2

POWER PLANT OPERATION LOG

WEDNESDAY (DAY) DEC 9 1914 (DATE)

OPERATING ENGINEER
10:30 P. M. TO 6:30 A. M. Lawrie
6:30 A. M. TO 2:30 P. M. Carter
2:30 P. M. TO 10:30 P. M. Bergin

TURBINES — AVAILABLE X, RUNNING √, CRIPPLED O

BOILERS — P. H. No. 1 600 H. P. UNITS; P. H. No. 2 2500 H.P. UNITS; TOTAL EQUIV. 500 H. P. UNITS

	LOAD			TURBINES										BOILERS											
	DELRAY	C. C.	TOTAL	1	2	3	4	6	7	8	9	K. W. CAPACITY IN SERVICE AT RATING	PER CENT LOAD TO CAPACITY	P. H. No. 1 AVAILABLE	P. H. No. 1 STEAMING	P. H. No. 1 BANKED	P. H. No. 2 AVAILABLE	P. H. No. 2 STEAMING	P. H. No. 2 BANKED	TOTAL EQUIV. AVAILABLE	TOTAL EQUIV. STEAMING	TOTAL EQUIV. BANKED	M LBS. STEAM BOILERS STEAMING AT RATING	M LBS. STEAM EQUIVALENT OF LOAD IN K.W.	PER CENT RATING OF BOILERS
A. M. 1	18000			√	X	√	X	√	X	X	X	32000	56.3	20	16	4	6	2	4	50	26	24	375	335	88.0
2	15900			X								23000	69.2	"	"	"	"	"	"	"	"	"	"	300	80.0
3	16800											"	73.0	"	"	"	"	"	"	"	"	"	"	315	84.0
4	15600											"	67.8	"	"	"	"	"	"	"	"	"	"	295	78.7
5	19000				√							32000	59.4	"	"	"	"	3	3	"	31	19	440	345	78.4
6	32200										√	47000	68.5	"	20	0	"	6	0	"	50	0	715	540	75.5
7	54700						√		√			70000	78.1	"	"	"	"	"	"	"	"	"	"	872	122.0
8	62900									√		84000	74.9	"	"	"	"	"	"	"	"	"	"	990	138.5

FIG. 2. POWER-PLANT OPERATION LOG

The boiler-room log sheet shows when the boilers were cut into the system or banked, the number of boilers steaming, etc. The engine-room log gives the throttle-steam pressures, first-stage pressures, bearing-oil pressures, etc., and the time the machines were started and stopped.

The screenhouse log contains a record of the amount of makeup water put into the system, the amount of barium hydrate with which this water was treated, the temperatures of the circulating water entering and leaving the plant, temperatures of makeup and surge well waters and the variation in level of the river water.

The switchboard log contains a record of the load on the machines and exciters and the load on outgoing feeders, similar to reports kept at any electric switchboard.

Fig. 2 shows the power-plant operation log kept by the operating engineer. This is the most important record of all, as it is a summary of all the other logs and shows the exact conditions under which the plant is operating.

The Weekly Maximum-Load Test

To further watch the condition of the main turbo-generators and their condensing apparatus, a weekly high-load test is made upon them. In this test all readings of pressure and temperature from the turbine and condenser are recorded, the water rate of the turbine not being taken at this time. It has been found by experience that the maximum load that can be carried on a machine continuously, other things being equal, is an indication of the condition of the machine. This maximum load is kept upon a machine until the temperatures and pressures adjust themselves to the maximum-load condition. This does not, of course, include the temperature of the generator windings, which naturally would continue to change with the length of time the maximum load was carried. When the maximum condition is reached (sometimes after 30 min.) readings are taken and recorded upon a report sheet similar to the one shown in Fig. 3.

The emergency trip on the governor is tried twice a month and is kept adjusted to trip out at from 65 to 66 cycles.

*Chief assistant engineer of the Edison Illuminating Co. of Detroit.

The leakage of cooling water into the steam side of the condenser is carefully watched, and weekly, daily or hourly tests are made of the water that is discharged from the wet pump of the condenser, to determine the amount of this leakage, if there is any. A sample of the

FORM 7208-3-24-14-1M

THE EDISON ILLUMINATING CO., DETROIT, MICH. — **DELRAY POWER HOUSE No. 2**

TURBO-GENERATOR LOG FOR 24 HOURS ENDING MIDNIGHT WEDNESDAY (DAY) DEC 9, (DATE) 1914

HOUR	BAROMETER	TURBINE No. 6				TURBINE No. 7				TURBINE No. 8				TURBINE No. 9				KILOWATTS LOAD			ENGINEER ON WATCH
		STARTED 12-55 6-19				STARTED 6-12 –				STARTED 7-18				STARTED 5-14				POWER HOUSE No. 1	POWER HOUSE No 2	TOTAL	6:30 A. M. TO 2:30 P. M. W. Crawford
		STOPPED 11-32				STOPPED –				STOPPED 9-20				STOPPED 12-15							2:30 P. M. TO 10:30 P. M. J. Marath
		RUNNING 17 HRS 46 MIN. IDLE " 10 " REPAIR " "				RUNNING 17 HRS 48 MIN. IDLE " 22 " REPAIR " "				RUNNING 14 HRS 2 MIN. IDLE " 15 " REPAIR " "				RUNNING 18 HRS 59 MIN. IDLE " 22 " REPAIR " "							10:30 P. M. TO 6:30 A. M. J. Callaghan
		PRESSURES				PRESSURES				PRESSURES				PRESSURES							
		THROTTLE	1st STAGE	STEP	Condenser in Abs.	THROTTLE	1st STAGE	STEP	Condenser in Abs.	THROTTLE	1st STAGE	STEP	Condenser in Abs.	THROTTLE	1st STAGE	STEP	Condenser in Abs.				
A. M. 1	29.5	197	31	925	0.9													10 000	8 000	18 000	REMARKS
2		200	42	950	0.9													7 000	8 900	15 900	#9 Turbine examined -
3		197	39	945	0.9													8 000	8 800	16 800	there is no trace of oil
4		196	40	948	0.9													6 800	8 800	15 600	working through any-
5		193	42	950	0.9													9 800	9 200	19 000	where
6		200	42	950	1.0									194	40	973	0.9	12 800	19 400	32 200	
7	29.50	197	47	955	1.0	197	47	870	0.9					200	50	980	1.0	23 900	30 800	54 700	#9 Circulating Engine and
8		192	45	950	1.0	194	47	870	0.9	194	53	970	1.0	196	43	973	0.9	21 900	41 000	62 900	Circulator. All bearings

FORM 657C

THE EDISON ILLUMINATING CO. DETROIT, MICH. — **DELRAY POWER HOUSE No. 2**

CONDENSER ROOM LOG FOR 24 HOURS ENDING MIDNIGHT WEDNESDAY (DAY) DEC 9 (DATE) 1914

HOUR	UNIT No. 6				UNIT No. 7				UNIT No. 8				UNIT No. 9				No 8 ELECT. B.F.P.	REMARKS
	R.P.M. D.V. PUMP 63		R.P.M. CIRCUL. PUMP 160		R.P.M. D.V. PUMP 63		R.P.M. CIRCUL. PUMP 162		R.P.M. D.V. PUMP 66		R.P.M. CIRCUL. PUMP 151		R.P.M. D.V. PUMP 63		R.P.M. CIRCUL. PUMP 162			
	WATER TEMPERATURES				WATER TEMPERATURES				WATER TEMPERATURES				WATER TEMPERATURES					
	Entering Condenser	Leaving Condenser	Leaving Wet Pump	Leaving B. F. Pump	Entering Condenser	Leaving Condenser	Leaving Wet Pump	Leaving B. F. Pump	Entering Condenser	Leaving Condenser	Leaving Wet Pump	Leaving B. F. Pump	Entering Condenser	Leaving Condenser	Leaving Wet Pump	Leaving B. F. Pump		
A. M. 1	39	49															156	#7 Condenser
2	39	50															162	washed, tested
3	39	50	63														166	Ferrel repacked.
4	39	50	62														149	
5	38	51	64														131	
6	38	51											38	50			170	
7	38	52	64	192	38	52	62					168	38	52	62			
8	40	53	64	190	40	54	64		40	53	60	172	40	53	62			

FORM 654F

63

THE EDISON ILLUMINATING CO., DETROIT, MICH. — **DELRAY POWER HOUSE NO. 1**

BOILER ROOM LOG FOR 24 HOURS ENDING MIDNIGHT WEDNESDAY (DAY) DEC 9 (DATE) 1914

BOILERS STEAMING ✓
BOILERS BANKED X
BOILERS NOT READY FOR OPERATION O BUT WITH FIRES ⊖.
BOILERS BLOWN B

HOUR	BOILER NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	NUMBER OF BOILERS POWER HOUSE NO. 1 READY FOR OPERATION	STEAMING	BANKED		FOREMAN ON WATCH
A. M. 1	✓	✓	✓	✓	✓	✓	O	O	O	O	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	X	✓	✓	20	16	4		6:30 A. M. TO 2:30 P. M. Plagues
2																													2:30 P. M. TO 10:30 P. M. Ross
3																													10:30 P. M. TO 6:30 A. M. Schultz
4																													
5																													
6																			B ✓	B ✓	B ✓	B ✓			"	20	0		REMARKS
7																													

FIG. 1. TURBO-GENERATOR, CONDENSER AND BOILER-ROOM LOGS

report made is shown in Fig. 4. A dionic water tester is used for this purpose and the conductivity of the water is measured. The conductivity of the river water under different temperatures and conditions of the river has been determined by a series of tests. A curve has been drawn showing the conductivity of the pure condensate diluted with known quantities of the river water. From this curve the percentage of leakage of condensing water can be determined, knowing the conductivity of the mixture that was drawn from the discharge of the wet pumps. To make results comparable; all readings are taken at the same temperature, which is 77 deg. F.

The quality of coal from each shipper is checked regularly by taking daily samples as it is unloaded from the cars. The bunker into which this coal was delivered is

recorded, and if it burns as previous experience has shown it should burn, these samples are averaged at the end of the week and the average sample is analyzed and reported as the quality of coal received from that shipper during that week. If the coal shows bad features, then the sample from these cars is analyzed separately and a report made as to the cause of the unusual conditions.

To get an average plant sample of coal, a small scoopful, about one pound, is taken twice on each shift from two places in the stoker hopper of each small boiler and from eight places in the stoker hopper of a large boiler at the time when they are steaming. These samples for each shift are kept separate in cans provided for the purpose, and at the end of each day are carefully mixed and a representative sample taken. At the end of a week these daily samples are carefully mixed and a representative sample taken and analyzed for moisture, ash and B.t.u. content. Some of these samples and also some of those from the different shippers are analyzed for the fusing point of the ash.

Samples of ash from each size of stoker are taken during each shift, and these are carefully mixed and a sample taken and analyzed for the carbon content.

From the plant log sheets and the analysis of the coal burned and the quantity of coal consumed after correcting for the coal in the bunkers at midnight of each Saturday night, the routine testing department makes a weekly power-plant report of the form shown in Fig. 5. This has become the most important record made, but only since the method of determining the quantity of coal in the bunkers at any time has been perfected so that the inaccuracy is such a small percentage of the quantity of coal burned during the week that it is practically negligible in its effect upon the results.

REPORT OF MAXIMUM LOAD TEST ON TURBO-GENERATORS
THE EDISON ILLUMINATING CO.

DELRAY POWER HOUSES, No. 1 AND 2 — DETROIT, MICH.

DATE DEC 11, 1914.

TURBO-GENERATOR NUMBER	1	2	3	4	6	7	8	9
KILOWATT LOAD	11,000	10,800	11,000	10,500		13,000	13,200	11,500
STEAM PRESSURE AT THROTTLE	188	190	192	188		193	191	192
STEAM PRESSURE FIRST STAGE	61½	60	62	61		60	71½	69½
STEAM PRESSURE SECOND STAGE	25	27½	25	19		23	23½	0
TEMPERATURE OF STEAM	640	560	570	570		530	530	548
BAROMETER READING	29.67	29.67	29.67	29.67		29.67	29.67	29.67
VACUUM UNDER LAST WHEEL	28.6	28.4	28.5	28.5		28.3	28.2	28.0
ABSOLUTE PRESSURE UNDER LAST WHEEL	1.07	1.27	1.17	1.17		1.37	1.47	1.67
VACUUM AT NORMAL LOAD	28.72	28.58	28.65	28.60	MACHINE NOT RUNNING	28.80	28.70	28.70
ABSOLUTE PRESSURE UNDER LAST WHEEL AT NORMAL LOAD	0.95	1.09	1.02	1.07		0.87	0.97	0.97
DROP IN VACUUM FROM NORMAL LOAD TO MAXIMUM LOAD	0.12	0.18	0.15	0.10		0.50	0.50	0.70
TEMPERATURE OF CONDENSATE	75	75	75	72		71	68	86
TEMPERATURE OF CIRCULATING WATER ENTERING	36	36	36	36		37	39	40
TEMPERATURE OF CIRCULATING WATER LEAVING	56	54	60	54		60	61	61
STEP BEARING OIL PRESSURE	920	850	1035	918		905	1040	1025
HYDRAULIC VALVES OPEN	16	16	16	16		17	18	16
BY-PASS VALVES OPEN	2	2	2	2		3	3	2
R. P. M. OF CIRCULATING PUMP	700	700	700	700		162	151	162
R. P. M. OF DRY VACUUM PUMP	65	65	62	64		63	66	63

REMARKS: Upper carbon rings on #2 and #9 Turbines need refitting.
Governor on #9 Turbine needs a general overhauling. Not working properly
Temp. inlet water 39.5°F Temp. outlet water 49.0°F

FIG. 3. REPORT SHEET FOR MAXIMUM LOAD TEST

REPORT OF LEAKAGE TEST ON CONDENSERS
THE EDISON ILLUMINATING CO.

DELRAY POWER HOUSES No. 1 AND 2 — DETROIT MICH.

DATE DEC 11, 14.

CONDENSER NUMBER	CONDUCTIVITY	TEMPERATURE	CORRECTION FACTOR	CONDUCTIVITY CORRECTED	% LEAKAGE	
1	4.25	71	0.965	4.10	TRACE	
2	4.0	69	0.980	3.92	TRACE	
3	3.5	70	0.977	3.42	TRACE	
4	4.5	65	1.038	4.67	TRACE	
6		MACHINE NOT RUNNING.				
7	2020 & 280	66	1.025	Av 2.450	11.5	
8	3.5	59	1.120	3.94	TRACE	
9	4.0	67	1.013	4.05	TRACE	
RIVER WATER	85					

REMARKS
One tube, one third distance up in lower right section left hand tube sheet
#7 Condenser, plugged - resulting in a reduction of Conductivity on Dec 12, 14 to 300

FIG. 4. CONDENSER-LEAKAGE TEST REPORT

OPERATING RECORD
THE EDISON ILLUMINATING CO.
DELRAY POWER HOUSES DETROIT, MICH.

DATE DEC. 5-12 incl 1914

POUNDS OF COAL PER KILOWATT-HOUR DELIVERED			1.847
B. T Us PER KILOWATT-HOUR DELIVERED			25,102
OVERALL THERMAL EFFICIENCY ENTIRE PLANT			13.59
OUTPUT			
GENERATED		K. W. H.	6,860,900
HOUSE SERVICE		K. W. H.	170,500
DELIVERED		K. W. H.	6,753,400
HOUSE SERVICE TO TOTAL GENERATED		PER CENT	1.574
AVERAGE OUTPUT PER DAY		K. W. H.	964,686
COAL			
COAL IN BUNKERS	Midnight December 5th	LBS.	15,748,400
COAL TO BUNKERS	December 5-12th Inclusive	LBS.	11,819,700
COAL CHARGEABLE	. . . . .	LBS.	27,568,100
COAL IN BUNKERS	Midnight December 12th	LBS.	15,094,000
COAL CONSUMED	December 5-12th Inclusive	LBS.	12,474,100
AVERAGE COAL CONSUMED PER DAY		TONS	891
COAL ANALYSIS			
TOTAL MOISTURE		PER CENT	2.953
ASH		PER CENT	8.190
HEATING VALUE	As fired (14004 dry)	B. T. U.	13,592
ASH ANALYSIS			
CARBON IN ASH P. H. #1	Stokers with periodic dumping	PER CENT	20.163
	Stokers with Cinder Grinders		10.770
CARBON IN ASH P. H. #2	Stokers with periodic dumping	PER CENT	21.775
	Stokers with Cinder Grinders		9.773

FIG. 5. TYPICAL WEEKLY POWER-PLANT REPORT AT DELRAY

Measuring Electrical Resistance of Earth—Oil in sand or earth causes it to have a very high resistance to the flow of an electric current, and certain ores cause it to have a very low resistance. For any particular specimen of earth the resistivity varies with the moisture content. The damage to pipe systems on account of electrolysis by the return current of street-railway systems depends, among other things, upon the resistivity of the earth around the pipes and near the tracks. In a recent publication of the Bureau of Standards, a way of measuring earth resistivity, which is free from some of the faults of methods which have previously been used, is described. The method is particularly adapted to those cases in which it is important that the measurement be made without disturbing the earth, as is necessary where a sample is taken into the laboratory for measurement, and in those cases where the mean resistivity of a fairly large portion of earth, extending to a considerable depth, is investigated.

Editorials

The Engineer's Employer

In other lines of industry many of the employers are giving bounteously of their interest, their time and their capital to so educate their employees that they may know more of their vocation, have a more-than-money interest in it and be loyal and steadfast.

In the field of the operating engineers this condition is sadly lacking. Here the employer, it would seem, directs his efforts mainly to the generating and transmitting machines. The "human machines" that operate them are none of his concern, apparently.

The fine work thus far accomplished by operating engineers has been due almost solely to their own efforts—through association work, individual study and at considerable expense. And all this has been attained outside of the long hours of day-in and day-out toil. In a few instances the employers have given these men some encouragement; in the many the employers have been utterly indifferent to their engineers' advancement.

This condition becomes all the more deplorable when it is contrasted with the assistance given to employees in other fields than our own, where there are industrial-training schools and free textbooks; technical classes in both theory and practice, in mathematics, drafting, English, etc.; time allowed to visit other plants to study the operation of new machinery, participate in tests, make analyses, attend lectures, and have free access to trade literature, etc.

The engineer cannot, unaided, completely educate himself; he must have the coöperation and encouragement of a loyal employer. Has he these aids at present?

It has been asked, Why educate the engineer while the employer remains ignorant? The engineer *must* be educated in order to perform properly his duties, as must be the employer in his. The employer's training, however, has stopped short of completion if he remains wilfully ignorant of his educational responsibilities to his employees, be he a public-service official, a manufacturer or an industrial manager. And it is this type of employer who usually reasons that "engineering" is an easily acquired trade, needs no special skill or encouragement, and can therefore be held cheaply.

The employer in nearly every other line of industry has wisely concluded that his human machines must be given the same unremitting attention that his mechanical devices receive if his particular industry is to be productive of best results. He is an educated, and therefore usually a thoroughly successful, employer.

Even the large department store—that mart of ribbons and laces, pots and pans—has its school for salesmanship, its teacher in bookkeeping and accountancy, its management classes, always teaching the "get-together" spirit of mutuality and coöperation to its "operating engineers." They all work together. To the average power-plant owner or manager, the men in the overalls are no more nor less than "the hands," and this average owner mixes with them as does oil with water.

Almost since the substitution of mechanical for muscular power, most employers have realized that mere dollars and cents are insufficient compensation for employees who give the best that is in them—skill, loyalty and faithful service—and they have resorted to every means to increase these qualities.

In our own domain no employer is asked to add a mixture of sentiment to his business, for "business is business," but it is naught else than good business to improve the man as well as the machine; to increase his intelligence that it may keep pace with the equipment he is expected to operate, for "whatever makes the worker more human, more contented, more skilled, is a positive industrial asset in the business and is a large factor in industrial stability."

But will the engineer's employer ever awaken to this reasoning? Will he cast down his wall of indifference and aloofness, come out in the open, confess his mistaken attitude, and help those who are helping him?

Water Power at Cohoes

The Cohoes water-power development, which is described in this issue, is an extension, or rather a reconstruction, of one of the oldest utilized water powers of any size in this country. As long ago as 1826 the New York State Legislature passed an act incorporating the Cohoes Company and giving it the right to utilize the bed of the Mohawk River adjacent to the great falls at Cohoes, where there is a total head available of about one hundred feet. The state reserved only the right to take at any time any additional quantity of water necessary for navigation. This provision was necessary because of the proximity of the Erie and Champlain canals, both of which pass through Cohoes and depend to a certain extent on the Mohawk River for their operation.

At first the falls developed a minimum of about ten thousand horsepower. This was used in a number of mills grouped along the banks of a canal taking water from above the falls. Each individual mill had its own water wheel and inefficient system of transmitting power to its machinery. Contrast with this the modern plant, which now has a capacity of thirty thousand horsepower and will eventually supply fifty thousand horsepower from its Francis water turbines. Electrical energy will be generated in alternators direct connected to the turbines and transmitted at twelve thousand volts to the mills.

The layout of the installation follows closely the best modern practice. Kingsbury bearings are used to support the rotor of the generating units. Oil at two hundred pounds pressure is supplied to the servomotors. It is noteworthy, however, that while the upper part of the oil tanks is filled with air under pressure, the oil pumps are of the ordinary triplex, rather than of the differential plunger type. The latter pump has been successfully used with air-filled oil tanks because of the decrease in the total volume of oil required.

Losses Through Leaky Valves

How many engineers have given consideration to the fact that frequently the difficulty in keeping up steam is, at least in part, caused by leaks through valves and pipe-line joints? Is it not true that hundreds of pounds of steam that could be returned to the boiler in the form of condensate is exhausted yearly to the atmosphere from open pipes? And is it not also true that all of the leaks could be stopped and that most of the escaping steam from the various machines, pots, vats, etc., could be handled by a trap and the heat contained in the condensate retained in the return water?

Probably textile mills are worse offenders, as regards unnecessary leaks, than any other kind of manufactories, and it is not uncommon to find the chief engineers down in the boiler room "jacking up" the firemen because they are unable to keep the steam in the boilers at the required pressure.

It is more than likely that "Mr. Engineer," if asked why he did not attend to leaking valves, etc., would reply that if he looked after such trivial matters he would have little time for anything else.

Although such an attitude may make it easier in some respects for him, it makes it harder for his assistants and increases the cost of operating the plant because of the excess consumption of coal and boiler-feed water. One leaky valve may not make much difference in the steam loss, but a number, each leaking a little, would require considerable extra coal. Most leaks can be easily stopped by substituting a new disk for the old, or by regrinding the valve seat.

There have been cases where leaks were caused, and the valve eventually ruined, by screwing down on the stem with excessive force, some engineers even going to the extreme of using a wrench on the handwheel to obtain a better leverage. Naturally, such abuse will spring the seat out of true and there is no doubt that many valves have failed, "from no apparent reason," because of this manner of handling them.

It is rare that a steam plant is visited that is free from visible leaks; in many they are pronounced jets of steam shooting into the air. With the visible leaks in such profusion, what can be expected of the leaks through the valves themselves?

An uptodate power plant was visited recently where but one slight leak was observed, and this the engineer said would be repaired just as soon as the line could be cut out of service. This engineer took a just pride in the fact that this plant was free, so far as known, of all but one extremely small leak, which, by the way, was unavoidable at the time and was not of long standing.

How many engineers can say that they know of no leaks in the pipe systems of their plants? How many have really tried to prevent them? How many know of leaks, but have not made an attempt to stop them, because they are indifferent and have little regard for the consequences?

Keeping valves and joints tight is as much an engineer's work as setting the engine valves and making out reports of the plant operation. Furthermore, it is his work because it is the right thing to do, and the real engineer will attend to it not only because it is his duty, but because he wants his plant to be mechanically correct in so far as it is within his power.

Smoke Standardization

While writers in numerous places and at various times have contributed much information about furnace dimensions and construction, rules for hand- and stoker-fired furnaces, locomotive practice, smoke ordinances—everything, in fact that tends to abate smoke—nothing compares with the possibilities of the standardization committee appointed at the recent convention of the Smoke Prevention Association, formerly the International Association for the Prevention of Smoke.

There are twelve subcommittees, each having a peculiarly fitted chairman who, in nearly every instance, is chief inspector of a large city. The aim of the committee is to investigate the working conditions under which all classes of steam generators make the least smoke, labor, location and character of fuel considered; to standardize a smoke density, very likely to be expressed in per cent., as is the Chicago practice; and to circulate its report for public benefit. The report will probably be submitted at the annual meeting in St. Louis next September and should be the most valuable piece of smoke literature available. Further particulars concerning the committee appears elsewhere in this issue.

⁂

Study Habit as Influenced by License Laws

The effect of a license law in stimulating engineers to apply themselves more thoroughly to their art is again illustrated in the report of the educational committee of the National Association of Stationary Engineers. Out of twenty thousand members, ten thousand engaged in the elementary- and advanced-problem competitions. Of thirty-four prizes awarded twenty-three went to men in states where license laws are thoroughly enforced, namely, Massachusetts and Ohio.

The industries of New England are so concentrated in a small area that the Massachusetts law makes active the desire to study in engineers in adjacent states. This is well-known; and the report mentioned confirms the belief. Twenty-two of the prizes went to Massachusetts, eleven to Connecticut.

⁂

That the Panama-Pacific, the most costly and beautiful of all international expositions, has burned its mortgage, thereby declaring its success, is deeply gratifying to every American. Science, the mechanic and other arts, the huge industries, the coöperation of many learned bodies—all have effected in a trying time an exhibition that will make a wide and shining mark in the world's Twentieth-Century history.

⁂

The American Manufacturing Co., of Brooklyn, N. Y., is shutting down a five-thousand horsepower plant and buying its current. A comparative statement of its combined heat and power accounts under the two methods of operation would be interesting.

⁂

We pay a heavy toll to experience to find out a lot of things we might easily learn otherwise but somehow won't.

⁂

Perhaps some men are really unlucky, but most of them just think they are.

Correspondence

Effect of Velocity Head on Centrifugal Pumps

The velocity head is often neglected in calculating centrifugal-pump tests. On the other hand, a large pump manufacturer, in finding the total head, includes the velocity head. In a test in which a manufacturer is interested, he will of course demand all that is coming to him. Smallwood, p. 293 of "Mechanical Laboratory Methods of Testing Machines and Instruments," in discussing such tests, says: "The total head includes the friction head of suction and discharge pipes and the velocity head, if it is large enough to be of consequence." Since power is required to accelerate or impart motion to the water, the question is whether in practice the velocity head is large enough to be of consequence and why and when it may be neglected.

Suppose that the gage on the discharge line shows a pressure equivalent to a 50-ft. head and that the gage connected to the suction line opposite the eye of the impeller shows a vacuum corresponding to a 20-ft. head. Let the distance from the center of the pressure-gage dial to the center of the suction pipe at the vacuum-gage connection be 2 ft.; then the total head is $50 + 20 + 2 = 72$ ft. Let the volume of water delivered, say 1000 gal. per min., correspond to a velocity of 11.3 ft. per sec. in a 6-in. discharge pipe and of 6.4 ft. per sec. in the 8-in. suction. Since the velocity head, or the head required to produce a given velocity, is $\frac{V^2}{2g}$, or $\frac{V^2}{64}$, we have for the suction, $h = \frac{6.4^2}{64} = 0.64$ ft. The water when delivered into the smaller discharge pipe has its velocity increased to 11.3 ft. per sec. The pressure head that would produce 11.3 ft. velocity from rest is $h = \frac{11.3^2}{64} = 2$ ft. This means that the pump finally gives the water a velocity sufficient to cause it to ascend 2 ft. higher than the distance indicated by the pressure gage on the discharge pipe, and therefore it should have credit for this head. But before adding the 2 ft. to the 72 ft. we must subtract our 0.64-ft. suction. The suction-gage reading includes a velocity head in the suction pipe, as will be explained later. Subtracting 0.64 from 2 gives 1.36, which added to our 72 ft., makes the total head 73.36 ft. The first result is thus increased almost 2 per cent. This error is not great and would be less with a higher head. As many other details may equally affect the results, the velocity head is frequently neglected. The error, however, is not accidental and may be either negative or positive. When the suction is smaller than the discharge pipe, measured where the gages are connected, the difference in velocity heads must be subtracted from the apparent total head. If both pipes are of the same size as the gage connection, subtracting the velocity heads will give 0 and there will be nothing to add to or to subtract from the apparent head.

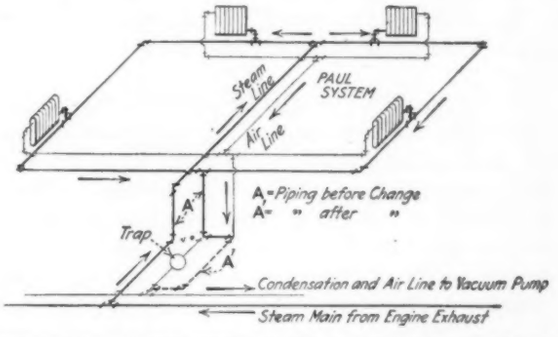
To understand why the velocity head in the suction pipe is included in the gage reading, suppose the pipe is full of quiet water held there by the external atmospheric pressure acting against a lower pressure in the pipe. The gage would show a vacuum corresponding to the height of the column of water between it and the level of the supply water. Suppose now the vacuum is increased so that the force acting will not only support but will also accelerate the water as it enters the suction pipe. The accelerating force that changes the water at the foot valve from a state of rest to a state of motion is applied at the pump runner. The gage would evidently feel this increase of vacuum and thus register the force producing velocity. This force is proportional to the velocity head and is therefore included in the suction-gage reading.

S. WILCOX.

Oakland, Calif.

Trouble in Combining Two- and Single-Pipe Systems

Seven buildings of a group are supplied with steam for heating from a central heating and power plant. Six are equipped with the Webster two-pipe system of heating and one with the Paul single-pipe air-return-line system. A new plant was installed and this required some changes in the piping connections. After these alterations were made considerable difficulty was experienced in heating



METHOD OF CONNECTING PAUL SYSTEM TO WEBSTER HEATING SYSTEM

the building equipped with the Paul system; this, too, in spite of the fact that this building is nearest the heating plant. The others heated nicely.

Exhaust steam from the engines and live steam from the boilers at reduced pressure enters the steam-heating main at pressures varying between 0 and 2 lb. A vacuum of from 5 to 10 in. is maintained on the return condensation line. An investigation to discover the cause of the difficulty in the heating of this building disclosed a peculiar pipe connection. There was no exhauster for the return air line, but it was intended to use the vacuum return line of the Webster system as the air exhauster for the Paul system. However, the air line from the radiators of this building was connected to the return end of the steam line directly ahead of a bucket trap that handled all of the condensation of the building. The returns from this trap passed directly to the main con-

densation line and from there to the vacuum pump. Air could not be exhausted from the radiator coils except when this trap operated. Consequently only a portion of the radiators would heat up, and those near the return end of the steam line would receive no steam whatsoever.

A temporary correction was made by disconnecting the air pipe and connecting it on the return side of the trap. The illustration shows diagrammatically the connections before and after the change. In my judgment it would be better to have a separate exhauster for the Paul system.

R. S. Hawley.

Golden, Colo.

Cutting Down Friction Waste

Call it waste, cost burden, overhead or whatever you will, one ever-present loss in connection with power production and transmission is found in friction. It is present all the time everywhere that machinery is in motion, and no man has ever devised any means for its entire elimination. It is practical in many places, however, to reduce it, and that is one of the "great games" of the day—to see how much friction can be eliminated. Friction that can be prevented by practical means costing less than it will pay in returns is waste.

Friction comes mainly from windage and resistance of journal bearings. The friction on bearings may be intensified by poor equipment, lack of lubrication, tight belts or unnecessarily heavy machine parts, and the windage or friction resistance of air is influenced by the design of moving parts. The power to operate idle machinery represents friction, and the important questions are, how much should the friction burden be in well-regulated plants and how may it be cut down to the minimum without having the expense in making changes act as a greater drawback?

The best general formula for effort of this kind is—reduce the size of shafting, reduce the weight of moving parts, and lighten the strain on belts. How this may be applied depends largely on local conditions. Wherever it is possible to cut out a countershaft or jackshaft and make the drive more direct, this will generaliy effect a reduction in the friction load. Roller and ball bearings constitute a proper and effective method for reducing friction. New shafting of the best quality so that it may be of the smallest practical size may cut out a lot of friction waste. Some of the older industries use shafting twice the size it should be.

Reducing the weight of pulleys helps cut out part of the friction load, and this and the reduction of the size of the shafting go hand in hand. Light shafting at higher speed is the order of the day—much lighter and at much higher speed than formerly. It used to be that in listing power transmitted by a line of shafting, speed tables seldom went beyond 300 r.p.m., while nowadays it is nothing unusual to find lineshafting operating at 600 to 900 r.p.m.

An idea worth considering in this connection, in plants where machines are used intermittently, is to have the lineshaft drive in the center and so connected that either or both ends may be cut in or out when desired, so that when the machines on one end are idle the lineshaft may be stopped. This can be done either with a belt drive to a central section or, where a line of shafting is motor-driven, by coupling the motor in the middle of the line, with a clutch at each end of the motor shaft.

Then there are the everyday matters of detail to be attended to. Take the journals and lubrication for example. While part of it is a matter of original selection, quite a lot of it is a matter of detail to be attended to—alignment, adjustment and lubrication. Lubrication and friction elimination should be made a serious study, for no matter what kind of machinery is being used or what the surroundings are, there is always a chance for effective work by a systematic study to reduce friction.

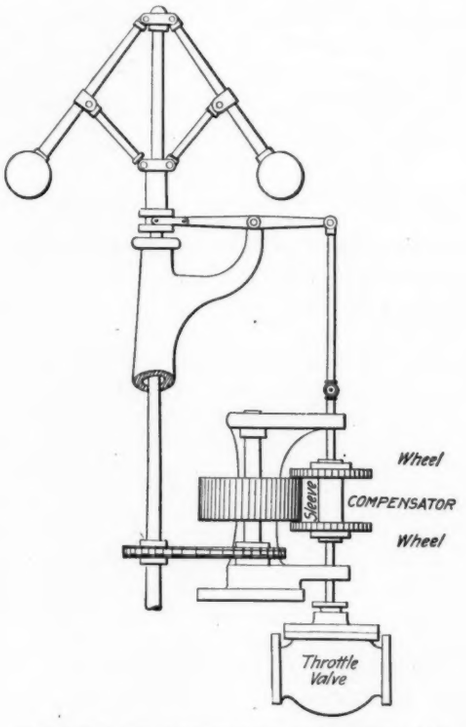
It is not enough to pour on a little oil now and then or screw down a grease cup without further attention. Carelessness in regard to these things has perhaps resulted in more unnecessary friction than anything else about the power plant. It may require argument and the consent of others to get changes made in machinery, but getting the best service out of present equipment is largely a personal matter.

J. Crow Taylor.

Louisville, Ky.

Pendulum Governor Compensator

I saw an interesting compensator on a large double-beam engine in a textile mill in England about 23 years ago. The engine was of the Watt and Boulton type and had been compounded by the addition of two high-pressure cylinders, which were placed about half way between the



DETAILS OF GOVERNOR COMPENSATOR

connecting rod and the beam trunnions, on the opposite side of the beams to the original or low-pressure cylinders.

All the valves on this engine were of the plain slide type, and the regulation was obtained by a double beat, or balanced, throttle valve, controlled by an ordinary Watts pendulum governor, gear driven from the engine shaft. I do not remember the cylinder dimensions, but

the engine ran about 45 r.p.m. and developed about 500 hp.

The governor compensator was mounted on the throttle-valve connecting rod between the governor and the valve. The rod was cut in two at this point and the two parts were coupled together by means of a right and left threaded sleeve about 8 in. long. On each end of this sleeve was keyed a friction wheel, and as the governor rose and fell the sleeve and its wheels moved with it, though in the opposite direction. Parallel with the throttle valve rod and about 12 in. from it was mounted a vertical shaft driven from the governor spindle by a chain and sprockets and a disconnecting clutch. Mounted on this shaft so as to engage either one of the two wheels on the throttle valve rod was a wide-face friction wheel. This wheel would just pass between the two wheels on the sleeve, but the slightest movement up or down of the sleeve would engage one or the other of the wheels and cause the sleeve to be revolved in one or the other direction.

By means of this arrangement, when an extra load was put on the engine, causing a drop in speed, the governor fell and lifted the throttle valve rod and opened the valve so as to give the engine more steam. At the same time it caused the lower wheel on the sleeve to engage the large wheel and be revolved in a direction to cause the throttle valve rod to be shortened, thus opening the valve wider and allowing the engine to speed up sufficiently to bring the governor back to the neutral plane. This moved the sleeve and brought the small wheel out of contact with the large one. The engine would thus be making the correct revolutions again, but the throttle valve would be open wider to accommodate the greater load. With a reduction in load, the action was, of course, just reversed and the valve closed to the correct point.

The action of this compensator was such as to cause the engine to revolve at the correct speed to keep the governor in the neutral plane; any other speed but the correct one would bring the compensator into action. Changes in load caused a momentary change of speed, just sufficient to start the compensator, when the speed would be brought back to normal at once.

As I remember, this compensator gave satisfactory service, and the speed did not vary between no load and full load. When starting and stopping, the compensator was thrown out of action by means of the clutch.

This same engine had also an electric stop. An independent weight closed the throttle with a releasing magnet. The current was obtained from a wet battery, and there were push buttons throughout the plant.

BENJAMIN S. HANSON.

Broad Brook, Conn.

An Intermittent Ground

A ground developed in a small single-phase motor running a pump. Several people had received shocks from the water pipe from the pump, which was supposed to be well grounded. A magneto would not show any ground in the motor and would ring well from the pipe to an independent ground, showing that the pipe was grounded. The shocks were intermittent and quite strong. By standing on a wet concrete floor and putting one hand on the pipe and leaving it there when the shocks were working, it was noticed that a shock would be felt only on the up stroke of the pump.

A careful examination of the motor showed that at times the centrifugal weights that flew out to lift the brushes off the commutator struck a high point of the windings. The motor was bolted, not very tightly, to a wooden frame, so that at times the thrust due to lack of alignment of the gears held the rotor at one end of its play, about 1/8 in., and at other times the thrust was the other way. Only on the up stroke was this thrust strong enough to hold the rotor way over so that the weights could hit the windings. The pipes were grounded through the well, but not enough to prevent a shock when the weights were touching the winding, and they would not touch when not running, so a magneto naturally was helpless.

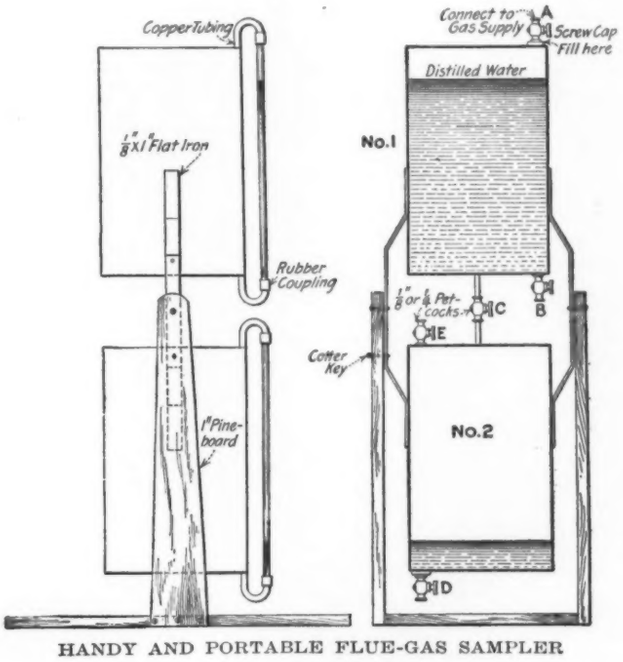
HARRY D. EVERETT.

Washington, D. C.

Flue-Gas Collector

A simple gas collector which can be regulated to give average samples of from one-half to two hours' duration is shown herewith. It is portable and more accurate than the old "snapshot" bottle method of obtaining samples.

The collector can be made large enough to give samples over a full day, but is not then portable. About one dollar was spent for material in the construction of this collector, although double this amount would be needed if everything were purchased. This is seldom the case, as most engineers can find scrap articles in their plants which will answer the purpose as well as new material.



HANDY AND PORTABLE FLUE-GAS SAMPLER

The first collector was made of two ordinary polish cans with a capacity of 1 gal. each. After a year's use the corrosive action of the distilled water, assisted by the gases, was enough to eat through the cans, so it was thought advisable to make them either of copper or of galvanized material. The ordinary kerosene cans of from 1- to 3-gal. capacity are made of galvanized sheet and can be bought at any tinware store. They make good sampling tanks.

The petcocks are standard brass ⅛ or ¼ in., having single male ends, except *C*, which has both ends female. These cocks are soldered to the cans or to the filling caps, the cans being connected by means of the cock *C* and two nipples, brass preferred. They are then connected by strips of flat iron, which hold the cans rigidly in place and at the same time provide means for swinging in the pedestal. The gage glass is connected as follows: Copper tubing, such as is used in lighting systems on automobiles, is bent U shape, as shown, and soldered to the can. A gage glass is then cut to fit between the tubes and is connected with common rubber tubing, which is afterward shellacked over to make it air-tight. This makes a neat and substantial job.

To operate, fill the tank top with distilled water and draw and discharge a few samples so that the water will absorb no CO_2. This will prevent false readings. To take samples, connect the rubber tube from the sampling pipe to cock *A*, making sure that all air has been cleared from the tube and sampling pipe. The sampling pipe should be provided with a petcock so as to prevent air leakage and assure a pipe full of gas at all times. Open the cocks *C* and *E*, which permit the water to start flowing from the upper to the lower tank, thus creating a vacuum in the upper tank. Cock *C* is then regulated to obtain samples over a certain period. By placing one's ear to the lower tank, the cock *C* can be closely regulated by controlling the number of drops per minute.

When the sample has been collected close all the cocks, disconnect the tube from the sampling pipe, pull out the lock pin and reverse the position of the tanks. Connect the tube from the analyzer to cock *B* and open the latter. Now open *D* and *C*, which will force gas to the Orsat. When the sample has been taken, close *B*, which will prevent the gas escaping. When sufficient samples are obtained in this manner, allow all the water to flow to the lower tank; reverse the tanks and all is ready to collect another sample. To make sure that all air is expelled from the tanks each time, have 1 in. of water in the upper tanks after the lower one is full.

F. W. Fischer.

Knoxville, Tenn.

Start a Steam Turbine Slowly

A number of articles have been printed in *Power* relative to the best methods of starting steam turbines, but many of them did not treat specifically enough of large and of small units. I have heard engineers tell of how quickly a large turbine was brought up to speed and fully loaded, and have wondered whether they thought of the risk they were taking with themselves and the unit, because of the rapid and uneven expansion of the elements of which the rotor is composed.

No turbine, large or small, should ever be started suddenly and placed in service. It should be started slowly and sufficient time given to uniformly heat the spindle, the time necessary being governed by the size of the machine and the length of the time that it was idle.

Small units will warm quickly, but should be warmed slowly to give the elements of which the rotor is built a chance to adjust themselves to the rapidly increasing temperature. With reference to large units, consider, for instance, one of 15,000 kw. and assume that it has been shut down for about twelve hours and that a signal has been given to put it in service. Large throttle valves are seldom tight, and during the twelve hours of idleness steam has been blowing on one side of the spindle, which is naturally distorted owing to uneven expansion. If this machine were brought up to speed rapidly, with a steam temperature of 500 deg. F. at the throttle, the rotor would be further distorted, likely causing the blades to rub and break off, also causing an increased vibration for a time until the spindle was uniformly heated, when the vibration would gradually diminish. The rotor of such a turbine is a built-up hollow cylinder, with the blading secured to the periphery and with a solid shaft at each end for the bearings. It is well known that to heat this, a large body of metal, uniformly and rapidly is difficult. The weight of a large spindle is about forty-five tons. I have noticed the marking on blade tips of spindles after they had been removed from the casing, and on one machine the marking followed the spindle like a spiral; and again the marking was on one side, indicating that the rotor was warped.

Picture a spindle capable of delivering 20,000 hp. being started and brought up to 1,800 r.p.m. in a few minutes, and then think of the physical changes that are taking place in the materials of which it is composed.

A safe way of starting a large unit, assuming that the spindle and field are well-balanced, is to increase the speed slowly, allowing from 10 to 20 min. before it is up to normal. If this method is followed the spindle is uniformly heated and there is no undue vibration when passing critical speeds. There is an idea prevalent among engineers that when the critical speed is reached a little more steam should be given to pass that speed quickly, but this is unnecessary.

Frank W. Wearin.

Brooklyn, N. Y.

Packing Centrifugal Pumps

After several years' experience with the different types and makes of centrifugal pumps, I have concluded that about nine-tenths of the trouble with them is from improper packing. Square flax is generally used, and this soon wears hard, cuts the shaft, leaks badly and has to be replaced frequently at considerable expense. Soft-flax packing soaked in oil and graphite gives better results, but it lasts only a short time. Such pumps must have a packing that will not get hard and can be tightened up and have additional rings put in at any time without stopping the pump.

We have a 5-in. double-suction centrifugal pump direct-connected to 15-hp. motor running at 1,800 r.p.m. supplying a barometric condenser, and considerable trouble was experienced with the packing wearing out, the pump taking air, losing the water and then, of course, the vacuum.

Square flax was the only packing sold in this district, but a can of rawhide packing was ordered from the factory and the pump packed with it. After two months' continuous running it is still in and is not leaking. It is found to be much more economical, as the old packing does not have to be pulled out and a new ring can be put in on top of the old and kept in the box till it is completely worn out, and the shaft is kept in a good condition.

Ed. M. Keys, Jr.

Montesano, Wash.

Smokeless Locomotive Operation Without Special Apparatus*

By H. H. Maxfield†

Eliminating objectionable smoke from steam locomotives is naturally divided into two parts—first, terminal, or engine-house operation; and second, road operation. Probably the more vital of the two is the engine-house operation, for the reasons that, owing to the cleaning and rebuilding of fires a large amount of objectionable smoke is apt to be produced; and furthermore, the success of the road operation depends largely on the condition of the locomotive, especially its fire, when it is turned over to the crew by the engine-house organization. Again, a locomotive is hours at the engine house to minutes in the smoke-restricted district while in charge of the crew.

If, therefore, the elimination of objectionable smoke can be accomplished at engine terminals and the locomotives turned over to the crews with fires in such a condition that it is not necessary to do much in the way of heavy firing while passing through the restricted area, the problem is more than half solved.

We will consider first, the terminal problem, and second, the road problem.

ESSENTIALS OF THE TERMINAL PROBLEM

The first essential is that the locomotive be delivered by the crew at the ashpit with the fire in good condition, that is, not badly burnt out nor yet full of green coal, but having a medium-sized, bright fire. This allows of the cleaning and banking with a minimum of smoke. It is obvious that a nearly burnt-out fire requires a large amount of coal to rebuild, thus increasing the liability of objectionable smoke; while in the case of a heavy green fire, the coal is already present, making it difficult to clean the fire without excessive smoke.

The second essential is the careful cleaning and rebuilding of fires, and banking in case the locomotive is to remain at the terminal for any length of time. These operations being completed, the locomotive is moved to the engine house or storage yard, and from then on until the crew assumes charge, the burden is on the engine watcher, who must see that the fire is properly maintained until the crew assumes charge. If the fire is properly cleaned, rebuilt and banked, the engine watcher has a simple problem confronting him.

The third essential is the proper preparation of the fire for service by the fireman upon taking charge of the locomotive. The first and second essential having been properly taken care of, the problem is not difficult.

Without going into details, the methods of cleaning, building up, banking, and the building of new fires as practiced at our engine terminals situated within the limits of the City of Pittsburgh are the result of much study and experimentation on the part of those in charge, including visits to terminals in other cities where the problem has been successfully handled, notably Washington, D. C. The instructions to those responsible follow:

RULES FOR CLEANING AND BUILDING FIRES

Cleaning Fires—When cleaning fires at the ashpits, the blower shall be used with sufficient strength to keep down black smoke. One-half of the fire shall be cleaned at a time. After the ashes are knocked out over one-half of the grate surface, this surface should then be covered with gas coal and a layer of low-volatile coal placed over this. The good fire should then be thrown over this coal to allow cleaning of the other half of the grate. After this half of the grate has been cleaned, it should be covered with a similar amount of gas and low-volatile coal, and the burning fuel on the opposite side pulled over it until an even depth of fire is obtained over the entire grate surface. If more coal is then needed to build up the fire the hostler shall use only low-volatile coal which has been thoroughly wet with water.

Banking Fires—All coal used for this purpose shall be low-volatile coal and shall be thoroughly wet with water. Banking shall be started at the rear end of the firebox and built forward until the fire has been covered within two or three feet of the front flue-sheet. The fire shall be heaviest along the side sheets and of minimum depth in the center. In case a banked fire needs more coal supplied, low-volatile coal shall be used exclusively. If there is no low-volatile coal on the tender, the hostler shall make report of this condition to the engine-house foreman and receive instructions.

Building Fires—The entire surface of the grate shall be covered with 3 in. of gas coal spread over evenly, and upon this an even layer of four or five inches of low-volatile coal thoroughly wet. Care shall be used to see that the coal is spread evenly so as to cover the entire grate surface, and that no holes are left in it. Dry shavings shall be distributed over the entire surface of the coal, care being taken that the shavings shall be placed along the side sheets of the firebox. One bucket of shavings, which has been mixed with one quart of fuel oil, shall be evenly distributed on top of the dry shavings. When this has been done the shavings should then be ignited by a small piece of waste thrown into the middle of the firebox. The blower should then be operated lightly until the coal shall have become ignited, when the strength of the blower should be increased gradually. The door shall be kept wide open when the fire is started, but after the coal has become thoroughly ignited, it may be closed, depending upon smoke conditions at the stack. Under no circumstances shall the fire be hooked. If more coal should be needed, wet low-volatile coal shall be supplied in small quantities. The house blower shall not be used if the locomotive in which fire is being built has 50 lb. steam pressure. When the pressure reaches 50 lb. the house blower shall be disconnected.

The use of low-volatile coal is to be noted. This coal contains approximately from 20 to 22 per cent. of volatile matter. The use of this coal, while not essential to the operation of locomotives at a terminal without objectionable smoke, is unquestionably a great aid, especially at congested points where it is necessary to handle a large amount of power in a minimum of time; and we feel fortunate, therefore, in that we are enabled to make use of it in working out this smoke problem.

The placing of a layer of gas coal on the grates under the low-volatile coal when building new fires as well as when cleaning fires, is an expedient for preventing the low-volatile coal, because of its fineness, from dropping into the ashpans, thus avoiding the necessity for a second cleaning. As the fire ignites from the top down, the volatile matter from the gas coal is ignited and consumed before passing out of the firebox.

The wetting of the coal is an expedient that has given excellent results from a smoke-prevention standpoint and has not produced injurious results.

To place low-volatile coal on the tender so that it will be accessible, special chutes were installed on the coal wharf, and in order that a limited supply may be accessible when needed, small platform bins have been erected at convenient points so that the hostler can obtain coal practically without getting off the locomotive. The low-volatile chutes on the wharf have been equipped with sprinkler pipes, so that the coal is wetted as it flows into the tender.

Our method of banking fires not only prevents, to a large extent, objectionable smoke, but also enables us to turn the locomotive over to the engine crew with a heavy bright fire that requires little working on the part of the fireman, and this enables him to avoid objectionable smoke.

Our 28th St., Pittsburgh, engine terminal handles, on an average, 175 locomotives in twenty-four hours. Approximately 35 new fires are built daily, about 75 per cent. of them being built out-of-doors. An average of one hundred engines per day have their fires cleaned or built at this point.

During the months of June and July, 1915, there were 403 observations taken at this point, of the smoke conditions of locomotives having new fires built in them, and in these observations but eight cases of smoke of No. 3 Ringelmann or greater density were noted. In none of these cases did this grade of smoke extend over one or two minutes, which is well within the requirements of the ordinance.

Since Jan. 1, 1915, no cases of objectionable smoke have been reported at our 28th St. terminal by the Bureau of Smoke Regulation. In order to keep the engine crews keyed up to the necessity of bringing locomotives to the ashpits with the fires in good condition, the head hostler examines practically all the fires of incoming locomotives and reports to the engine-house foreman all cases where the fires are not up to standard. These cases are referred to the road

*Read before International Association for the Prevention of Smoke, Cincinnati, Sept. 9.

†Master Mechanic, Pennsylvania R.R., Pittsburgh Division.

foreman of engines for investigation and such action as may be necessary to prevent a repetition. In addition to this, the smoke inspector, located at this point, makes an average of about 85 observations daily of smoke conditions, which are forwarded to the master mechanic and road foreman of engines. This inspector also devotes a large portion of his time to instructing hostlers and firemen in the proper methods of doing their work.

HOW THE ROAD PROBLEM IS HANDLED

The topography of Pittsburgh seriously complicates the problem of smoke regulation. To quote from Bulletin No. 8, "Smoke Investigation," by Mellon Institute of Industrial Research, in which is set forth some "Engineering Phases of Pittsburgh's Smoke Problem."

The topography of the city affects materially the operating conditions of the railroads and complicates the problems of smoke elimination. The various terminals of the railroads are situated not far from the junction of the two rivers and at comparatively low levels. Practically all trains leaving the city and going eastward are required to ascend heavy grades and pull around sharp or long, sweeping curves. It is necessary to exert a heavy pull from the time a train starts until it has passed beyond the city limits. This necessitates heavy firing and is responsible for a large amount of smoke and cinder. All the roads leaving the city have their tracks along the base of hills or in valleys between the hills. The contour of the district is such that there is a tendency to pocket the smoke and cinder in the valleys or deposit them over residential sections immediately overlooking the same. Residents on the top of the hills suffer heavily from the smoke made by locomotives in the river valleys. In every case where a railroad passes a city park the grades are steep for outgoing trains. This calls for heavy firing and very often the aid of a pusher locomotive to help freight trains over these grades.

Starting from Pennsylvania Station as a center, the Pittsburgh Division extends east through Shadyside, Roup, East Liberty and Homewood, passing out of the city limits west of Wilkinsburg, a distance of six miles over a generally ascending grade, the maximum being 1.7 per cent. Just east of East Liberty Station, the Brilliant Branch runs north a distance of 3.4 mi., crossing the Allegheny River and connecting with the Conemaugh Division; also connecting with the Conemaugh Division tracks running north on the east bank of the Allegheny River. The grade on this branch is 1.4 per cent., ascending southward. The 28th St. engine house and shops are located 1.1 mi. east of Pennsylvania Station; right in the heart of the city.

The Western Pennsylvania Division, Pennsylvania Railroad Lines East of Pittsburgh, has at present 1,040 active locomotives, any or all of which are liable to be operated within the limits of the city. Of this number, 590 are equipped with brick arches only, while 231 are equipped with brick arches and superheaters.

Locomotives in passenger service use gas coal, locomotives in freight service use run-of-mine coal, while those in shifting service within the city limits use low-volatile coal, except a few operating over the Duquesne Elevated, which use coke for fuel.

Briefly, the problem is handled as follows: Each division handles all smoke-regulation matters arising within its own operating territory. Frequent consultations are held by interested officers of the various divisions, in order to harmoniously handle the interdivisional problems. Trips by special train are made by these officers over the lines within the city limits, in order to study the conditions as they exist and evolve methods to improve them. At intervals a large number of special observers are stationed at the various strategic points for several days at a time, to obtain exact data on the smoke situation, in order that intelligent information may be had as to the progress being made. In addition, each division has its own corps of smoke inspectors, whose entire time is given up to taking smoke readings and instructing crews in the proper method of firing and handling locomotives to reduce the smoke to a minimum.

The railroads coöperate with the Bureau of Smoke Regulation of the City of Pittsburgh through its chief, Mr. Henderson. Copies of daily reports of smoke inspectors are forwarded to the bureau. (A sample of this report, which was adopted at the suggestion of Mr. Henderson was shown). This report, showing as it does, in detail the observations taken, the smoke readings, character of service, location, criticisms made or instructions given, enables the bureau to keep in close touch with the situation on the railroad, keep record of the progress made in the elimination of objectionable smoke, and gives the railroads an opportunity to know their shortcomings and correct them.

During the first six months of 1915 over 88,000 smoke observations were made; 674 enginemen and firemen were criticized for unsatisfactory smoke performance; 9,725 enginemen and firemen were instructed in the operation of locomotives so as to avoid objectionable smoke; 333 enginemen and firemen were disciplined for inexcusable unsatisfactory performance; and 9 shopmen were disciplined for the same cause. All enginemen and firemen have been given printed instructions covering the proper method of firing and operating locomotives in order to obtain efficient and smokeless operation. The essentials of these instructions follow:

The burning of bituminous coal in a locomotive requires air, which must be admitted through the grates and through the fire door.

Smoke means waste of coal and must be avoided.

Large quantities of coal placed in the firebox at one time cool down the fire, cause smoke and waste coal; small quantities at regular intervals will keep the fire bright, prevent smoke and take less coal to keep up pressure.

Lumps of coal should be broken in pieces not larger than three inches.

A bright and level fire over the whole grate must be carried whenever possible. When a sloping fire is used no more coal should be banked at the door than is necessary.

To prevent smoke and to save coal, the fire-door must be placed on or against the latch after firing coal or using the scraper, slash bar or hook, and when on sidings, in yards, at terminals, or before starting.

Before the throttle is closed the blower must be used and the door placed on latch. Fireman must stop firing long enough before steam is shut off to prevent smoke and waste of coal.

The grates must be shaken as often as necessary to clear the fire of ash and clinker to admit sufficient air, and in such manner as to avoid the loss of good fire. Care should be taken to place the grates level after each operation.

Coal can be saved by the proper use of the injector in pumping locomotive regularly, and by taking advantage of opportunity to fill boiler when not working locomotive to full capacity; also by using injector to avoid the safety valves blowing off.

Coal will be saved by always working the locomotive (except when starting) with a full throttle when the cutoff is one-quarter of the stroke or greater; but if one-quarter cutoff with full throttle gives more power or speed than is needed, the reverse lever should be left at one-quarter cutoff and the throttle partially closed as needed.

The railroad feels that considerable progress has been made in the effort to eliminate objectionable smoke, the best proof of this being the fact that during the first six months of 1915 there was a reduction of over 78 per cent. in the number of complaints of objectionable smoke received from the Bureau of Smoke Regulation as compared with the last six months of 1914.

In conclusion, it can be said that the spirit of coöperation exists between the Bureau of Smoke Regulation of Pittsburgh and the railroad officers has been responsible, in the greatest measure, for the results obtained.

Uniform Boiler Legislation

Thomas E. Durban, chairman of the Committee on Uniform Standard Specifications of the United Boiler Manufacturers Societies, has just made a trip to the Coast in the interests of a wider adoption of the American Society of Mechanical Engineers' Boiler Code. A conference with representatives of the American Uniform Law Association dispelled any hope of aid from that direction, as they are trying simply to rewrite common laws so that they will be acceptable to, and can be passed in, all the states and will not concern themselves with any new legislation. In California, John R. Brownell, commissioner of public safety, expects the committee which he has appointed to accept the new part of the Code absolutely, but to make some changes in the part relating to old boilers, as they feel that the Code is rather drastic in this particular. Rulings on this portion will be changed from time to time by Mr. Brownell's commission, so that ultimately the Code will be in operation in its entirety. They expect to adopt it and make it operative by the first of January, 1917.

In Oregon five efforts have been made to pass a boiler code through the legislature, but it is expected that the next legislature will put it into the power of the State Labor Bureau, of which O. B. Hoff is commissioner, to enforce a boiler code, and it is understood that the commissioner appreciates the value of that which has been devised by the American Society. In the State of Washington, the cities of Seattle, Spokane, and Tacoma all have boiler laws, and while a Seattle boiler will pass in Tacoma and Spokane, a Tacoma or Spokane specification will not fully satisfy the Seattle inspectors. The state authorities are alive to the necessity and the desirability of having a standard boiler code throughout the state.

Smoke Inspectors' Convention

At the Sinton Hotel, Cincinnati, Ohio, Sept. 8-10, the tenth annual convention of the International Association for the Prevention of Smoke was held. During the convention the association's name was changed to the Smoke Prevention Association.

At 10 o'clock, Wednesday, Sept. 8, Louis C. Towner, president of the association and smoke inspector for Grand Rapids, Mich., called the convention to order. Addresses of welcome were made by Mayor Frederick S. Spiegel, of Cincinnati; William F. Ray, chairman of the United Smoke Committees of Cincinnati and the Smoke Elimination Committee of that city's chamber of commerce, and by Louis T. More, president of the Cincinnati Smoke Abatement League. The remainder of the morning was devoted to business, while during the afternoon the following papers were read:

"Civic Phases of the Smoke Question," by John O'Connor, Jr., Mellon Institute of Industrial Research, University of Pittsburgh; "Value of Organization in Smoke Abatement," by William A. Hoffman, smoke inspector, St. Louis, Mo.; "Starting the Work of a Smoke Department" by Martin A. Rooney, smoke inspector, Nashville, Tenn.; "Value of Publicity in Smoke-Abatement Work," J. W. Henderson, Pittsburgh, Penn. Mr. Henderson's paper was indeed interesting as showing the possibilities in smoke reduction by publicity campaigns well directed. (See "Power," Aug. 3, 1915, p. 152.) While similar in subjects, the papers of Messrs. Hoffman and Rooney treated smoke-inspection work from different angles. In the evening the United Smoke Committees gave a pleasing reception to all visitors. The ladies spent the afternoon visiting the Rockwood Pottery and Art Museum.

Thursday may properly be called locomotive day, for in the morning four excellent papers on smoke abatement as related to railroad practice were read and discussed. They are: "Smokeless Locomotive Operation Without Special Apparatus," H. H. Maxfield, Master Mechanic, Pennsylvania R.R., Pittsburgh, Penn.; "Various Methods of Eliminating Smoke from Chicago Roundhouses," by a representative of the Lake Shore & Michigan Central R.R.; "Smokeless Operation of Locomotives in Washington, D. C.," J. W. Henderson; "What Railroads Have Done to Abate Smoke," G. H. Funk, general railway smoke inspector, Cincinnati.

H. H. Maxfield's paper was received with profuse commendation by some and with astonishment by others. When he told of taking 10-steel-car trains six miles out of the city over a 1 per cent. grade without firing them, Mr. Lewis, of the Chicago, Burlington & Quincy, Chicago, confessed that it could not be done in his city and was prone to question the statement. It was confirmed by others present who had visited Pittsburgh. Other interesting information brought out by Mr. Maxfield was that at Pittsburgh they were able to build a fire in a locomotive filled with warm water and get up working pressure in 45 min., using low-volatile (20 to 22 per cent.) coal, without making smoke of a density which violates the ordinance. By careful firing and cleaning, fifty and more locomotives, all under steam, are kept in one yard during part of each day without producing objectionable smoke. Mr. Maxfield's paper appears elsewhere in this issue.

M. D. Franey, master mechanic of the Michigan Southern Division of the Lake Shore and Michigan Southern R.R., read a paper descriptive of a smoke washer applied in the roundhouse at Englewood Station, Chicago. This will also appear later in "Power."

During the afternoon of Thursday a visit to the smoke inspectors' observatory in the tower of the Union Central Building was enjoyed by all. From here the whole city, which is sunk in the hills, was visible, also the winding Ohio River and the hills and adjacent towns in Kentucky. Later, automobiles took visitors to the suburbs and the Zoo. On their return some enjoyed motion pictures of smoke devices and of stacks of plants and locomotives in which they were located.

A short but highly interesting paper of a statistical nature on "Enforcing a Smoke Ordinance" was read Thursday evening by S. H. Viall, formerly assistant chief of the Chicago Smoke Inspection Department. This paper will be published later in "Power." Osborne Monnett, formerly chief of the Chicago Smoke Inspection Department and now low-pressure and experimental engineer for the American Radiator Co., read a most interesting paper entitled "Effect of Furnace Design on Fuel Economy and Smoke Abatement in High- and Low-Pressure Work." Several specific plants were discussed and illustrated to show the effect on operating costs of various changes in design and methods. Mr. Monnett's paper will also appear in "Power."

Friday, Roy L. Peck, chief engineer, Great Lakes Dredge and Dock Co., Chicago, read a paper on "Smoke from Lake and River Steamboats," and A. W. Clement, of Des Moines, one on "Smokeless Combustion as Applied to Burning Clay Products."

The most important business done by the association was the appointment of a standardization committee, with Martin A. Rooney, smoke inspector, Nashville, Tenn., chairman. The committee consists of eleven subcommittees as follows: Smoke ordinance, John O'Connor, Mellon Institute of Industrial Research, University of Pittsburgh; firebox heating boilers, William A. Hoffman, chief smoke inspector, St. Louis; locomotive practice, J. H. Lewis, Chicago, Burlington & Quincy R.R., Chicago; steam jets and siphons, W. E. Porter, assistant chief, Smoke Bureau, Pittsburgh; arches and dutch ovens, Frank Chambers, M. E., Chicago Smoke Inspection Department; horizontal return-tubular boiler settings, Louis C. Towner, chief smoke inspector, Grand Rapids, Mich.; chimneys and flues, O. Monnett, low-pressure engineer, American Radiator Co.; front-feed stokers, J. W. Henderson, chief, Smoke Bureau, Pittsburgh; side-feed stokers, Charles H. Heath, chief smoke inspector, Cincinnati; chain-grate stokers, W. A. Pittsford, Kewanee Boiler Co., Chicago; underfeed stokers, Charles H. Bromley, associate editor, "Power," New York.

The following officers were elected: President, William A. Hoffman, St. Louis; vice-president, Charles H. Heath, Cincinnati; secretary-treasurer, Frank A. Chambers, room 608, City Hall, Chicago. The next annual meeting will be in St. Louis. An exhibit of smoke appliances and furnaces was a feature of the meeting.

Some Facts About Asbestos

Fifty years ago there was practically no asbestos industry, but the yearly output now runs in value well into the millions of dollars in America alone, while every civilized community in the world uses the mineral in various forms. Although there is evidence that this material was known and used by the Egyptians and their contemporaries, it was almost forgotten for many thousand years, until quite recent times. Asbestos is found in many countries, but much of it is either unsuitable for manufacturing purposes or else difficult to mine and transport, greatly restricting the output.

The history of Canadian asbestos mining may be almost described as a chapter of accidents. But for the burning away of the forests and the denudation of the overlying strata of soil and gravel, it is highly probable that the existence of asbestos deposits would not have been suspected.

Asbestos lies in veins or pockets varying in width from 1½ to 4½ in., sandwiched between layers of hard, semi-volcanic serpentine, which in this particular section is exposed on the surface of the ground at many points. Owing to the irregularity of the veins, mining by means of shaft or tunnel is practically impossible and the open-quarry system is almost universal, despite the drawbacks incidental to bad weather and the long winter season. The crude asbestos, as mined, is a rough block and its extraction involves the removal of a great deal of valueless serpentine rock, traces of iron and other metals—frequently as much as ten or twenty tons of waste to one ton of asbestos ore.

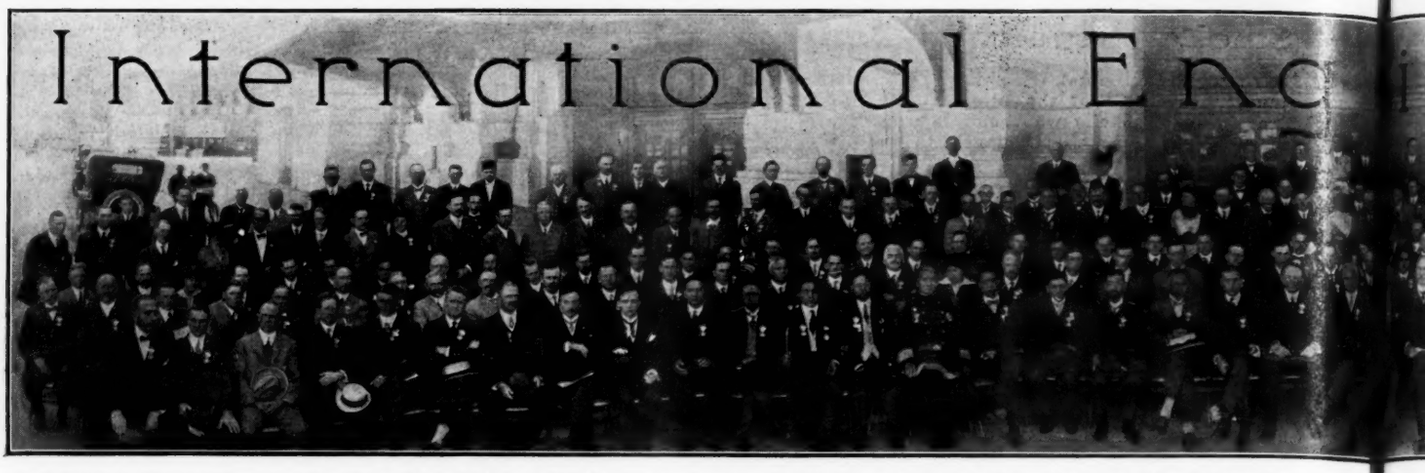
The finest pieces are first hand-treated with hammers. This removes the external impurities and is known as "cobbing." The lower grades are sent direct to the crusher, following which in both instances they go through the crushing, drying by centrifugal machinery, and fiberizing process for breaking up the fiber into threads in a similar manner to the beating of flax and hemp.

The fiberized asbestos then goes to a "cyclone," which agitates it violently with blasts of air and in the end tosses the lighter, silkier fibers one way and the coarser ones another, while the dust and refuse fall out below. From the "cyclone" the fine fibers drop into a shaker, which further agitates and separates them. Thence they are lifted by powerful fans. The finer particles traveling farthest are caught in one compartment, while the less fine are separated into various grades. This completes the milling process, and the crude asbestos is ready for manufacturing purposes.

Chemically, asbestos is a silicate of magnesia, with slight traces of other minerals, combined with a variable percentage of water. The larger the proportion of combined water the longer and more flexible are the fibers.

Engineers are familiar with numerous uses to which asbestos is being adapted, yet the list of possibilities is far from being exhausted.

The United States Produced 66.36 per cent. of the 400,483,489 bbl. of petroleum that entered the markets of the world in 1914, according to statistics compiled under the supervision of J. D. Northrop of the United States Geological Survey.—"Engineering Record."



Following the opening session (reported in the Sept. 28 issue) a reception to the visiting members was held on Monday evening, Sept. 20, at the Palace Hotel, followed by dancing.

Six different sections held their first sessions on Tuesday morning, namely: Waterways and Irrigation, Railway Engineering, Materials of Engineering Construction, Mechanical Engineering, Mining Engineering, and Naval Architecture and Marine Engineering. Of these the mechanical-engineering session was of closest interest to readers of "Power," but even this was confined to manufacturing, the papers dealing with foundry and forge-shop subjects. The papers at this session were: "Recent Advances and Improvements in Founding," by Thomas D. West, Cleveland, Ohio (deceased since the preparation of the paper); "Forgings from Early Times Until the Present," by C. von Philp, South Bethlehem, Penn.; "Recent Progress and Present Status of the Art of Forging with Special Reference to the Use of Quick-Acting Forging Presses," by A. J. Capron, Sheffield, England; and "Permanent Shops, Pacific Terminals—Panama Canal," by H. D. Hinman and A. L. Bell, Canal Zone, Panama.

In the afternoon the same sections held their second sessions with the addition of the first sessions of the sections on Municipal Engineering and Metallurgy. No papers of particular interest to the power-plant field were offered at any of these sessions, those in the mechanical-engineering section also being entirely on machine-shop subjects as shown by the following list of papers: "Machine-Shop Equipment, Methods and Processes," by E. R. Norris, East Pittsburgh, Penn.; another on the same subject, by H. F. L. Orcutt, Rowington, Warwickshire, England; "Automatics," by R. E. Flanders, Springfield, Vt.; and "High Temperature Flames in Metal Working," by H. R. Swartley, Jersey City, N. J.

THIRD MECHANICAL-ENGINEERING SESSION

Diesel engines and steam turbines were the principal topics at the third session of the Mechanical-Engineering Section. The first paper was a very comprehensive one prepared by Professor Lucke, of Columbia University, under the title, "The Internal-Combustion Engine of the Year 1915. The Gas Power System. A Survey of its Status in the Year 1915."[1]

R. Seshasayee, from India, gave an interesting account of experience with Diesel engines in his country, where difficulty has been encountered with different types of Diesel engines, mostly of English make. It was his opinion that the inlet valve should open about 10 deg. before the beginning of the suction stroke and that the exhaust valve should open 45 deg. before the end of the explosion stroke and close 10 deg. after the end of the exhaust stroke. He stated that he would be glad to get particulars of engines in this country that would be suitable to introduce in his country.

W. D. Peaslee believed that American manufacturers have attempted to reduce sizes of parts and so cheapen construction without, however, meeting the quality of workmanship of foreign engines. In his opinion the weights and costs cannot be reduced successfully unless a high class of workmanship and the best materials are employed.

The next two papers were presented in abstract by the secretary of the session, Professor Eckart, and discussed together. Their titles were: "The Development of the Construction of Turbines in the Netherlands,"[1] by D. Dresden, Hengelo, The Netherlands; and "The 1915 Steam Turbine,"[1] by E. A. Forsberg, Stockholm, Sweden.

F. L. Williams asked what efficiency is obtained with the electric drive in marine propulsion from steam turbines; to which W. J. Davis replied that the generator efficiency is 98 per cent. or better and the induction-motor efficiency depends on the speed. On the "Jupiter," where the propeller speed is only 90 r.p.m., the motor efficiency is not so high as it would be where the propeller can run faster. He does not think we can look forward to the time when merchant ships will have electric drive, because the propeller speeds are too slow. In such applications mechanical speed-reducing gears are probably better. G. W. Dickie disagreed with this statement and thinks that there is a future for the electric drive in merchant ships. It possesses many advantages and a reduction of 18 to 1, or something like that, should prove commercially economical. He does think, however, that the electric drive will be applied only for reasonably high powers.

The last paper of the morning was "The Diesel Engine In America,"[1] by Max Rotter, St. Louis, Mo., which was devoted largely to current features of design. H. J. Kennedy declared that cost is one of the many factors in connection with the use of Diesel engines upon which a great deal depends. He wanted to know if any information on this point had been brought out and asked if the cost of plant has been reduced any in the last few years. F. L. Williams gave the figure for the cost of Mietz & Weiss semi-Diesel engines as about $45 per horsepower.

A. V. Youens invited any who are interested to visit the Palo Alto mun'cipal plant[2] where there is in operation a 300-hp. Koerting Diesel engine, using crude oil of as low as 14 deg. Baumé. It is a small lighting plant running day and night. Saturday forenoons stops are made, and each week one of the four pistons is removed and the carbon scraped from the piston and around the rings. The cylinders are horizontal, and it is easy to take out the pistons. It may not be necessary to do the cleaning as often as this, but at first they had some trouble caused by pistons seizing, probably due to their not using the best lubricating oil for the service, but now they are having no difficulty, since they keep the pistons clean. The engine cost $14,360 in Germany and the generator $2,200. The whole expense of installation, foundations, switchboard, etc., was about $30,000, making the installed cost about $100 per horsepower. The foundation is cork-filled to prevent vibration. The fuel consumption is about 0.385 lb. of oil per brake horsepower-hour.

Simultaneously the sections on Water and Irrigation Engineering, Materials of Engineering Construction and Naval Architecture and Marine Engineering held their third sessions; those on Municipal Engineering and Mining Engineering their second sessions and the Miscellaneous section its first session, at which a symposium of papers on aviation was considered.

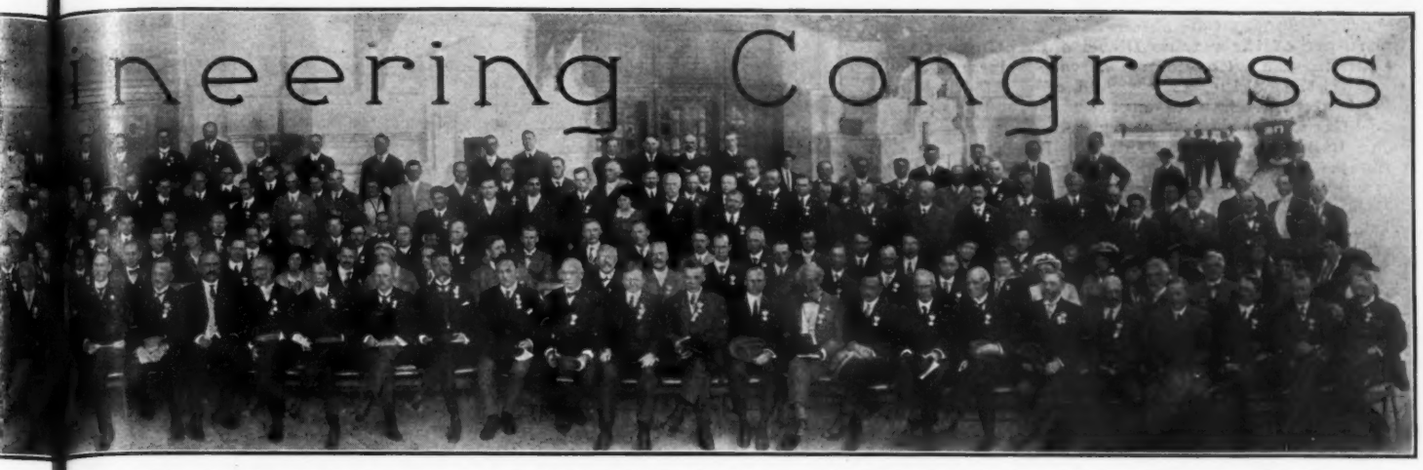
In the afternoon in the Court of Abundance of the Exposition the ceremony was held of presenting a bronze medal to Doctor Brashear as the foremost citizen of Pennsylvania for his contribution to the general welfare of that state.

FIRST ELECTRICAL-ENGINEERING SESSION

There was no mechanical-engineering session Thursday forenoon; of the eight other sessions, those on electrical engineering, and naval architecture and marine engineering, included papers in the power-plant field. H. F. Parshall, of London, England, presented a paper on "Economics of Electric Power-Station Design[1]," which dealt with the use of apparatus for obtaining economies, the determining considerations being the load factor and the cost of fuel. With regard to centralization of power supply, he believed this to be largely a matter of compromise between the economies effected and the cost of distribution. As an extreme example of lack of centralization, he cited the conditions in London, where there are 45 sep-

[1] An abstract will appear in a later issue.

[2] Described in "Power," Apr. 13, 1915.



arate electric companies, employing a great variety of voltages and frequencies, and making general inter-connection impracticable. None of these stations possesses facilities for generation on a large scale, and their average load factor is only about 21 per cent., which the author believes, by the proper centralization, could be increased to at least 28½ per cent.

The next paper was on "The Water Power of Sweden," by Sven Lübeck, and translated by C. J. Rhodin. This took up the available power in Sweden and the extent to which it is used, as well as the regulations governing the use of water powers in that country. In the discussion these water powers were contrasted with those on the Pacific Coast, and it was pointed out that the latter had the advantage of being free from much of the winter troubles that confront the former.

Charles H. Mitchell's paper on "Electric Power in Canadian Industry,"[1] was presented by the author's brother, H. Mitchell, This reviewed the utilization of hydro-electric power in the different industries and showed that Canada was not only second to the United States in hydro-electric power available, but was also second in the power developed, the estimated developed power in 1915 being 7,000,000 hp. for the United States and 1,700,000 for Canada. Canada, however, is ahead of the United States in the horsepower developed per capita, this being 0.21 as against 0.076, and is second only to Sweden, which has developed horsepower per capita to the extremely high figure of 0.487. The author noted that the water-power rights have remained mostly under the control of the Government, which policy has given reasonable protection to the public as to rentals, periodic revisions, control of rates, limited grants, etc., and at the same time has fostered legitimate private enterprise to return reasonable profit. The work of the Hydro-Electric Commission of Ontario was also reviewed.

"The Effect of Hydro-Electric Power Transmission Upon Economic and Social Conditions, with Special reference to the United States,"[1] was the title of the next paper, by Frank G. Baum.

MARINE BOILERS AND MARINE TURBINES

At the naval-architecture and marine-engineering session, held simultaneously, the first paper was on "Marine Boilers and Boiler-Room Equipment," by Charles F. Bailey. This reviewed the various types of marine boilers in use and showed that although there had been considerable development in marine boilers, both of the Scotch and the water-tube types, during the last decade, these improvements had been less marked than had the changes in propelling machinery during the same period; and the changes in the Scotch type had been still less than in the water-tube type. Due to the facilities of modern rolling mills it is now usual to construct single-ended Scotch boilers up to 12 ft. in length and nearly 18 ft. in diameter. The use of water-tube boilers in merchant vessels is increasing, thus permitting a large saving in weight and space. The Howden draft for merchant work is still favored. Important improvements have been made in feed-water heaters, feed pumps and forced-draft fans, and the use of superheated steam is increasing, the author believing that a saving in fuel of 8 to 15 per cent. is possible by its use. The standard types of boilers as adopted by the different navies were listed.

Regarding boiler corrosion, the author believes that this may be minimized by freeing the boiler of air, in which connection it is important to stop all air leaks in the pipe connections, condensers, etc. Heating the water tends to drive out the air, and this is one of the advantages of the use of feed-water heaters. It is also advantageous to admit the feed to the steam space, or slightly below the liberating surface of the water, to allow the contained air to separate out.

In discussing the foregoing paper, C. W. Dickie considered the Scotch marine boiler as having been neglected, and he believed a simpler type of superheater was needed. Attention was called to the fact that Lloyd's register shows that 88 per cent. of the boilers in use are of the Scotch type. Rear-Admiral Capps said that the Scotch boiler was not adapted to navy work, because with it steam could not be raised quickly enough, and also because saving of weight and space were of vital consideration in this case.

The next two papers were "The Development of the Marine Steam Turbine,"[1] by H. C. Dinger, and "The Application of the Steam Turbine to Marine Propulsion,"[1] by J. F. Metten.

FOURTH MECHANICAL-ENGINEERING SESSION

The fourth mechanical-engineering session was held on Thursday afternoon, the first paper being on "Developments in Modern Water-Turbine Practice,"[1] by Dr. H. Zoelly, which reviewed modern practice in water turbines, dividing the subject into three sections—low-, medium- and high-head types. Automatic governors were also discussed. "Water Wheels of Pressure Type"[1] was the subject of the next paper, by Arnold Pfau. This went somewhat into the design of these wheels, followed by a classification of the types and their characteristics. In discussing the selection of types the author paid a tribute to the progressiveness of American engineers. Speaking of efficiencies, he pointed out that 80 per cent. with a modern Francis turbine is common, and that 90 per cent. is obtainable with the single-runner vertical-shaft turbine. The last two papers were discussed jointly. J. D. Galloway believed that American designers have reached the highest efficiency they can hope to attain, and wished that the engineering societies might coöperate in formulating standard definitions relating to hydro-electric work. W. A. Doble stated that California had developed jet deflectors and deflecting nozzles for Pelton wheels before they had been used in Switzerland.

The next paper was by J. D. Galloway, on "Hydro-Electric Power Development and Its Use,"[1] which set forth the general engineering features of hydro-electric power development, described several typical plants and included a very useful table of data on high-, medium- and low-head plants in use in this country. In discussing this paper Mr. Doble pointed out the advantages of the lap-welded penstocks over riveted ones; they are smoother and thus reduce the loss due to the friction head and make possible a smaller and lighter pipe. The other two papers of this session were "Water Wheels of the Impulse Type," by W. A. Doble, and "Canadian Hydro-Electric Power Development," by Charles H. Mitchell.

At the sixth naval-architecture and marine-engineering session on Friday morning, the first paper was on "Fuel Oil," by E. H. Peabody. This contained statistics of the world's fuel-oil supply from its earliest history to the present and gave an interesting comparison of the cost with oil and with coal. Oil analyses and heating values were listed, and the relation of the flash point to atomization was discussed. Specifications of the United States Navy for fuel oil were included, with descriptions of oil-burning installations on a United States torpedo boat destroyer and a battleship. The author considered mechanical atomization as the most economical.

The next paper was by G. C. Davison on "The Application of Diesel or Heavy Oil Engines to Marine Propulsion."[1] This was followed by a paper on "The Diesel Motors Applied to Marine Purposes,"[1] by C. Kloss, who reviewed the Diesel installations in merchant ships up to the present time and gave a brief outline of the performances of these ships, with special reference to the Werkspoor engine. In discussing the

paper Lieutenant-Commander Shayne stated his belief that the future of the marine Diesel engine in marine propulsion lies in its use with electric drive. This would considerably simplify the engine, as it would eliminate reversing.

The sixth mechanical-engineering session was held on Friday afternoon, the first paper being by Arthur D. Pratt, on "The Boiler of 1915."[1] This was followed by two papers, namely: "Compressed Air in the Arts and Industries," by W. L. Saunders; and "Equipment, Processes and Methods for Boiler Shops," by E. C. Meier. At the fourth miscellaneous session on Friday afternoon, E. P. Lesley presented a paper on "Developments and Progress in Scientific Management During Recent Years." A written discussion by W. N. Polakov took up scientific management as applied to public utilities. Only recently, he said, the problems relating to the management of central stations and power plants have been attacked by scientific analysis. With equipment more or less standard, it had previously been assumed that results would follow automatically and that further studies hardly seemed warranted. Unlike manufacturers, public-utility companies rarely know the cost of their output minutely. However, he believed the situation was changing.

The remainder of this session was taken up by three papers on heating and ventilating: An introductory paper by Prof. R. C. Carpenter; "Recent Developments in Heating and Ventilation Art," by D. D. Kimball; and "Vacuum, Vacuo-Vapor and Atmospheric Heating Systems," by J. D. Hoffman. The first paper reviewed the general character of improvement during the last decade, and predicted that advancement must be on scientific lines. Greater accuracy is now required in computing the heat necessary to warm buildings, and in ventilation the carbon-dioxide standard is no longer the criterion. The author predicted that cooling systems will be used extensively in the future. Mr. Kimball pointed out that carbon dioxide is now shown not to be essentially harmful and is only an index to the change of air.

THE BANQUET AND THE CLOSING SESSION

Friday evening a banquet was held at the Palace Hotel. General Goethals, who was to have been the guest of honor, was unexpectedly called away, and an address by Brigadier-General Sibert, who was in charge of the Atlantic division of the canal construction, was substituted. The foreign vice-presidents were represented by Major Jean De Pulligny, of the French Army. Other addresses of the evening were by Prof. C. D. Marx, president of the American Society of Civil Engineers; Chester Rowell, representing the State of California, M. M. O'Shaughnessy, representing the city of San Francisco; H. T. Scott, the Exposition; and Benjamin Ide Wheeler, president of the University of California. The toastmaster was Prof. W. F. Durand.

The closing session of the congress was Saturday morning, at which farewell messages were delivered by Prof. Marx for the civil engineers, Dr. Brashear for the mechanical engineers, J. J. Carty for the electrical engineers, Jean De Pulligny and other foreign representatives.

OBITUARY

CORNELIUS J. FIELD

Cornelius J. Field died Sept. 18 at his home in Brooklyn. He was born in Chicago in 1862, and after graduating from Stevens Institute in 1886 entered the employ of the Edison Co. as draftsman. In 1889 he became chief engineer of the Edison United Manufacturing Co., and the following year he was appointed general manager of the Brooklyn Edison Co. In 1891 Mr. Field resigned to do construction work, and for the next few years he was engaged in building electric railroads and street-lighting systems in Buffalo, Newark, Worcester, Bridgeport, Philadelphia and other cities. In 1905 he went to Cuba and the West Indies, where he did construction work. Mr. Field later spent some time in Paris and in London, studying the omnibus system of those cities, and when he died he was president of the Electric Omnibus and Truck Co.

TRADE CATALOGS

L. J. Wing Mfg. Co., 352-362 W. 13th St., New York. Bulletin No. 38. Fans. Illustrated, 18 pp., 6x9 in.

Erie City Iron Works, Erie, Penn. Catalog. Steam engines, boilers, feed water heaters, tanks. Illustrated, 40 pp., 6x9 in.

Alberger Pump and Condenser Co., 140 Cedar St., New York. Bulletin No. 20. Hammond water meters. Illustrated, 24 pp., 6x9 in.

Link-Belt Co., 39th St. and Stewart Ave., Chicago, Ill. General Catalog No. 110. Elevating and conveying machinery, power transmission machinery, etc. Illustrated, 576 pp., 6½x9½ in.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1096. Direct current motors and generators. Illustrated, 20 pp., 8x10½ in. Bulletin No. 1635. Hydro-electric plant of the Cerro de Pasco Mining Co. Illustrated, 16 pp., 8x10½ in.

NEW EQUIPMENT

N. H., Georges Mills—Arthur S. Stocker applied to Public Service Commission for permission to install electric-light system.

Mass., Ludlow—Ludlow Electric Light Co. plans new power house on upper East St.

N. Y., Buffalo—Buffalo Cold Storage Co. will build power house. Estimated cost, $45,000.

N. Y., Buffalo—Lackawanna R.R. Co. will build power station on Ohio St.

N. Y., Olean—Contract awarded for power house for Higgins Memorial Hospital. Estimated cost, $16,000.

N. Y., Rochester—Contract awarded for power house for Gleason Works.

N. Y., Warsaw—Warsaw Gas and Electric Light Co. applied to Public Service Commission to install electric-light plants in Warsaw and Gainesville.

Penn., Philadelphia—Contract for electrical equipment for six-story building at 11th and Race St. awarded to UNITED ELECTRIC CONSTRUCTION CO., Philadelphia.

Del., Harrington—Fire, Sept. 11, destroyed plant of Harrington Water and Light Co. Loss, $8,000.

Del., Wilmington—Plans being prepared by Peucket & Wunder, Arch., Philadelphia, Penn., for baking plant, stable and power house for William Freihofer Baking Co.

Md., Baltimore—Carnegie Steel Co. plans storage building and power plant on Wicomico St. between Bush and Elk St.

W. Va., Martinsburg—Martinsburg Power Co. will be reorganized under the name of the Potomac Light and Power Co. Plans being considered for improving four existing dams and five plants of company. Estimated cost, $100,000.

N. C.—Lumberton—Bids will be received by city until Oct. 12 for improving municipal electric-light system.

N. C., Granite Falls—Granite Falls Mfg. Co. plans to equip its cotton mill with electrically driven machinery. Estimated cost, $40,000.

Ga., Cornelia—Wafford Shoals Light and Power Co. plans to double transformer capacity of its plant at Wafford Shoals, near Baldwin.

Ala., Fairhope—Citizens voted to issue bonds for municipal electric-light plant.

La., Nachitoches—Electric Co. will add 100-kw. generating unit eo its plant.

Tenn., Chattanooga—Chattanooga and Tennessee River Power Co. plans to install four general electric generators at its Hales Bar plant.

Tenn., Nashville—City will purchase new stokers for power plant of electric-light system.

Ky., Johnson City—City considering municipal electric-light plant.

Ky., Louisville—Louisville Water Co. plans new pumping station. Estimated cost, $750,000.

Ohio, Cincinnati—STANDARD ENGINEERING CO., at $203,855, awarded contract for mechanical equipment, including power plant and electrical equipment.

Ohio, Lima—Public Service Director authorized to engage engineer to prepare plans and estimates for municipal electric plant to supply electricity for ornamental street lighting system to be installed in business district.

Ohio, West Salem—West Salem Light and Ice Co. granted franchise for electric-light plant in connection with ice factory.

Mich., Morley—A number of Detroit business men are negotiating for the purchase of dam and flowage rights of Little Muskegon Power Co. If same is purchased power plant will be built. Estimated cost, $30,000.

Ill., Dixon—Bids will be received until Oct. 18 by Board of Administration, Capitol, Springfield, for power house, laundry building, cold-storage building and bakery on site of State Colony for Epileptics, about three miles north of Dixon.

Ind., Portland—City Engineer authorized to prepare estimate of cost for extension to municipal power house to provide space for transformers.

Wis., Fulton—Press reports state that local plant of Janesville Electric Co. has been damaged by flood.

Wis., Haugen—Franchise granted Wisconsin-Minnesota Light and Power Co., of Eau Claire, for electric-light and power plant.

Wis., Maiden Rock—Permission granted L. Mathys to construct and operate electric-light plant.

Iowa, Marathon—Citizens voted to issue $12,000 bonds for municipal electric-light plant.

Iowa, Perry—Iowa Railway and Light Co. plans an expenditure of $60,000 for improving electric-light plant.